THE RAILROAD AND
ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 145 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid.....$3 00
Subscription, per annum, Foreign Countries..... 3 50
Single copies..... 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

NEW YORK, SEPTEMBER, 1889.

IT is stated that the plans for the two large vessels authorized at the last session of Congress have been completed, at least in general outline. The larger, or 7,500-ton ship, will be a 17-knot cruiser, about 315 ft. long, carrying several 12-in. guns and a secondary battery. This vessel will somewhat resemble the English *Warspite* class.

The smaller, or 5,300-ton ship, will be about the same length, but lighter, and built largely for speed. She will be heavily engined, is expected to make 20 knots, and in general plan resembles the *Reina Regente*, a Spanish cruiser which has attracted much attention. Her battery will include two 10-in. and a number of rapid-fire guns.

THERE seems to be a prospect of resumption of work on the tunnel under the Hudson River between New York and Jersey City. The company, it is stated, has succeeded in raising money to go on with the work, and hopes to complete it in two years. The work was first begun in 1873, but not much was done until 1879; it was stopped in 1882, and was resumed for a short time in 1887.

The intention is to make two separate tunnels, each of which will be 5,600 ft. long under the river, without counting the shore approaches, which will be about 4,000 ft. long on each side of the river.

The work heretofore done was begun on the New Jersey side of the river, and the completed sections include 2,060 ft. on the north tunnel and 585 ft. on the south tunnel. On the New York side all that has been done is a short section of about 75 ft., on the north tunnel. The work now begun is in the north tunnel from the New Jersey side, the object being to complete that one before beginning on the other.

THE Navy Department will send out an expedition to observe the total eclipse of the sun, which will take place on December 22 next. The place selected is in the Portuguese possessions on the west coast of Africa, and the naval officers and scientific men who will compose the expedition will be taken to St. Paul de Loanda on one of the new cruisers. The necessary permission has been obtained from the Portuguese Government, and arrangements for the expedition are now being made.

THE agitation with regard to the improvement of country roads in New Jersey resulted in the passage by the last Legislature of a road law, which is, however, permissive and not mandatory in its provisions. This law permits the Board of Chosen-Freeholders—which, in New Jersey, corresponds to the Board of Supervisors or the County Court in other States—to assume control of all, or any part of, the roads in a county, and to provide for their improvement and maintenance by a county tax; thus taking away the management of those roads from the township and district authorities, who have heretofore controlled them. The county authorities are authorized to lay out new roads and to make alterations in existing ones should it be deemed expedient, and the law also directs the employment of a County Engineer, to have immediate charge of the work, and to act as adviser to the Board in locating and managing the roads.

This law is a step in the right direction, and if it is acted upon to any extent, there is little doubt that the advantages of transferring the control of the roads from the District Roadmaster or the Town Board to the larger and more comprehensive unit of the county, will be so evident that the system will be generally adopted. Not only can the roads be better laid out and better managed, but the possibility of employing a competent engineer will naturally lead to the adoption of better locations and better plans for maintenance and improvement.

As to the expense, the new law provides that one-third of the cost of building and maintaining each county road shall be assessed on the township or district through which the road passes, and the remaining two-thirds upon the county at large, a division which seems to be as nearly founded in justice as any general rule of the kind can be.

The model which led to the adoption of this law in New Jersey was probably the success of the Essex Road Board, which was established by a special law several years ago, and under which there has been constructed in the County of Essex in that State an admirable system of roads leading to Newark as a center, and giving all the principal towns and villages of a populous district a far better built and managed system of roads than had been before supposed possible.

THE Morris Canal, one of the oldest artificial waterways in the country, is probably to be abandoned as a transportation line. It has been for some years past leased by the Lehigh Valley Railroad Company, and its importance as a carrier of coal has diminished in consequence of the diversion of that traffic to the railroad lines which are now everywhere parallel to it. The canal is about 100 miles long, extending from the Delaware at Phillipsburg to the Hudson at Jersey City, and in its day was a notable engineering work.

The eastern half of the canal, which draws its supply of water from the hill country of New Jersey, is to be used as a conduit to carry water to the large cities bordering on New York. A contract has already been concluded for the supply of the city of Newark, and negotiations are pending for that of Jersey City. Both of those cities now use water from the Passaic River, which is barely sufficient in quantity, and the quality of which suffers from the pollution inevitable in a river flowing through a very thickly

inhabited region. The new source of supply will be abundant in quantity and of great purity, coming from a mountain region where there is little or nothing to cause pollution, and where there are already large natural reservoirs, while as many artificial ones as may be needed can be supplied at small expense.

THE Pennsylvania Railroad Company proposes to add to its Relief Association a system of pensions for employés incapacitated for work by old age and long service. The details of the plan are not yet announced, but it is said that they will include a contribution by the company to the funds of the Association to assist in the establishment of the new feature.

THE German railroads reported for the year 1888 a total of 4,577 breakages of tires on wheels of all descriptions, on a total length of 25,330 miles worked. Most of these breakages had no serious consequences, as only 26 derailments and 268 delays are reported as having resulted from them.

For several years past the number of tire failures has been gradually decreasing. Last year, however, they showed an increase, the average having been 87 per 1,000 kilometers of single track, against 70 in 1887. This is attributed to the unusual length and severity of the winter last year, and it is stated that out of the 4,577 breakages 3,492, or 76¼ per cent. of the total, occurred in the winter months.

LAST month we published some account of the great topographical map of France, which has been completed, and of the new one on a larger scale, which has been undertaken by the Geographical Corps of the Army. In the United States a similar work is now in progress. The topographical surveys upon which the map is based have been completed in Massachusetts, Rhode Island, and New Jersey, and partially made in Pennsylvania, New York, Connecticut, Maine, and New Hampshire. It may be noted that in the three States, the survey of which has been completed, one-half of the expense in each case was borne by the State. The maps of the first three named States are partly engraved; they are made on a scale of 1 in. to the mile, which is somewhat smaller than in the French maps, which are to be on the scale of 1:50,000. These maps will be published in sheets measuring 13 × 17½ in.—that of Massachusetts requiring about 50 sheets; of Rhode Island, 15, and of New Jersey, 50.

The atlas of the whole country will comprise about 2,500 sheets of the dimensions already given. Those of the Eastern States will be on a scale of 1 in. to the mile; the central and southern portions of the country, and the Pacific Slope on a scale of 1 in. to 2 miles, while the region formerly known as the Plains—that is, between the Missouri River and the Rocky Mountains—by a scale of 1 in. to 4 miles. The work is under the direction of the United States Geological Survey, and the topographical work is considered as a necessary preliminary to the completion of the geological work.

FAST ocean passages are the order of the day just now, and the performance of the new steamers is looked for with interest. The great steamship *Teutonic*, of the White Star Line—which is described in another column—made a most excellent record on her first trip westward, having made the run from Queenstown to Sandy Hook in 6 days 14 hours and 23 minutes. This is extraordinary time for a new ship, and indicates great speed hereafter, especially as the voyage was made against head-winds and fog was met for 17 hours. The daily runs of the *Teutonic* were 394, 404, 430, 431, 440, 454, and 227 knots. The average speed for the whole run—2,780 knots—was 17.53 knots per hour; the average for the best day's run was 18.92 knots an hour.

The *Columbia*, a new steamer of the Hamburg-American Line, also made an extraordinary run for a first trip, her time from Southampton to Sandy Hook being 6 days 21½ hours. The whole distance made was 3,064 knots, and the average speed was 18.5 knots an hour.

THE latest suggestion for the increase of rapid transit facilities in New York is the addition of a second deck or upper story to the present lines, on which fast or express trains could be run. The objections to increasing the height of the lines will suggest themselves at once to any one familiar with the city, and there is also the consideration whether an entire rebuilding of the present structures would not be required; but the idea is worth considering.

THE question of liability for the Johnstown disaster may be settled in the courts, a suit having been begun by the heirs of one of the victims to recover damages from the South Fork Fishing Club, the association which owned the dam, the failure of which caused the accident. The legal questions to be settled are many and complicated, and a long and involved law-suit may be expected.

RAILROAD STATISTICS.

FOR years past the Introduction which has accompanied the yearly volume of *Poor's Manual* has combined in tabular form the statistics of the railroads furnished to the *Manual*, and this compilation has really been the only statement of the business and condition of the railroads of the United States as a whole. The defects of this statement have before been pointed out, but with those defects—which mainly arise from the fact that the figures are voluntarily furnished and not official—the Introduction has always been valuable, and the publishers deserve much credit for the care taken in its preparation.

This year the figures of the *Manual* are supplemented by the publication of the first annual report of the Statistician of the Interstate Commerce Commission. It will be remembered that the Commission some time ago called for returns from the railroad companies, and the results of those returns are presented in Mr. Adams's report.

The Interstate Commission returns were received from companies owning or operating 139,102 miles of railroad, and the Statistician estimates that there were in addition 10,800 miles of railroad, making a total of 149,902 miles. The figures for capital, earnings, etc., given in his tables are from returns received from 136,884 miles of road.

On the other hand, *Poor's Manual* reports the total mileage of railroad in the United States at 156,082 miles, but its figures are not all based on that mileage.

The Commission reports have the advantage that they cover a uniform year (that ending June 30, 1888), and were made on a uniform plan; but *Poor's* reports, while they do not cover a uniform year, are generally brought

up to a later date, the majority of the companies covering the calendar year 1888 with their figures.

With these facts understood, it will be interesting to make some comparison of the two sets of figures, giving the stock, debt, earnings, and expenses of the railroads of the United States :

	Commission.	*Poor's Manual.*
	136,884 miles.	154,276 miles.
Stock	$3,864,468,055	$4,438,411,342
Funded debt	3,869,216,365	4,624,035,023
Floating debt	396,103,311	306,952,589
Total	$8,129,787,731	$9,369,398 954
Per mile of road	59,392	60,731
Earnings :		(145,341 miles.)
Passengers	$277,339,150	$251,356,167
Freight	613,290,679	639,200,723
Other sources	19,991,391	60,065,118
Total	$910,621,220	$950,622.008
Working expenses	594,994,656	653,258,331
Net earnings	$315,626,564	$297,363,677
Other receipts	89,593.471	84,897,880
Total	$415,220,035	$382,261,557
Fixed charges	285,492,433	288,610 506
Surplus	$129,727,602	$93,651,051

The surplus, according to the Commission report, was 3.35 per cent. on the stock, but this was probably greater than the real return. According to the *Manual*, the dividends actually paid amounted to $78,943,041.

Some of the discrepancies in the above tables arise without doubt from differing methods of classifying earnings, etc., and from the arrangement of figures under varying heads.

According to the Commission returns the railroads derived 30.46 per cent. of their earnings from passengers, 67.35 per cent. from freight, and 2.19 per cent. from other sources. The division of working expenses was : Maintenance of way, 22.60 per cent. ; maintenance of equipment, 17.09 ; conducting transportation, 50.26 ; general expenses, 9.34 ; miscellaneous, 0.71 per cent.

The traffic figures given by *Poor's Manual* are of interest as showing the extent of business done by the railroads :

Train mileage	688,751,371
Passengers carried	451,353,655
" " one mile	11,190,613,679
Tons freight carried	589,398,317
" " " one mile	70,423,005,988
Average passenger journey	24.78 miles.
" freight haul	119.48 "
" receipt per passenger per mile	2.246 cents.
" " per ton per mile	0.907 "

The averages given show to how great an extent the local or short traffic still exceeds the through business, and also how small the average return on all the business is. No feature of the yearly returns has been more striking than the steady reduction of the earnings per unit of traffic, and it is growing each year more evident that profits on the vast capital invested in railroad business depend upon the closest economy and the use of the best appliances for working.

From 1882 to 1888 the total freight traffic of the country increased a little over 79 per cent. ; but the average freight rate in the same time decreased very nearly 27 per cent. Had not there been also a decrease in the cost of doing the work, the business of 1888 would have shown no profit whatever—in other words, the average rate per ton per mile of 1888 was little or nothing above the average cost per ton per mile of 1882.

This reduction has been the result of causes too many and complex to permit their discussion here. That unrestricted railroad building and the consequent competition are the chief ones need hardly be said. Railroads have always possessed great attraction for capital, and it has been invested in them, often, it would seem, without due consideration as to whether a profit might be expected or not.

IRON AND STEEL PRODUCTION.

THE figures collected by the American Iron & Steel Association for the half-year ending June 30 last show that the production of pig iron in the United States for that period, compared with both the first and the second half of last year, was as follows :

	Net Tons.	Gross Tons.
First half, 1889	4,107,889	3,667,767
Second half, 1888	3,886,004	3,469,646
First half, 1888	3,382,503	3,020.092

The output of pig iron this year was greater than in any previous half-year in the history of the iron trade. The increase over the first half of 1888 was 725,386 net tons, or 21½ per cent. ; over the second half, 221,885 tons, or 5¾ per cent.

The stock of pig iron unsold on June 30 was, however, 502,934 gross tons, an increase of 202,790 tons in the six months, this increase being almost as great as that in production.

The same authority gives the production of Bessemer and Clapp-Griffiths steel in the United States for the half-year as below, in tons, comparisons being made with the first half of 1888 :

	1889.	1888.	Increase.
Bessemer	1,382,359	1,348,218	34,141
Clapp-Griffiths	38,356	36,070	2,986
Total	1,420,715	1,384,288	36,427

Of the total production this year, Pennsylvania is credited with 930,748 tons and Illinois with 245,171 tons, the remaining 244,796 tons being made in other States.

While the total steel production thus shows an increase of over 2½ per cent., the production of steel rails decreased 55,689 tons, or 7¼ per cent., having been 719,572 tons this year against 775,261 tons for the first half of 1888.

The general deductions to be drawn from these figures can be easily made. We know that there was a considerable falling off in the demand for iron for railroad purposes, while the fact that the increase in stocks on hand was almost exactly the same in amount as the increased production, shows that the actual consumption of pig iron in the first half of the present year was very nearly the same as in the first half of 1888. The falling off in the railroad consumption must thus have been made up by the increase in the demand for other purposes, and here it must be remembered that the use of iron as a structural material is growing rapidly every year. In our more important buildings iron beams are taking the place of wood. Iron bridges are everywhere replacing wood, and new uses for metal are being found every day. In all this there is much to encourage the iron manufacturer in the future ; and while the railroad interest will doubtless remain their largest single customer, yet they will be every year less and less dependent upon that interest for the condition of their business.

The same thing may be said of steel. As will be seen from the table above, the production of steel showed a fair increase this year, while the demand for steel rails, on the

other hand, fell off considerably. This may well be accounted for by the increasing use of steel for boiler plates, for bridge work and other purposes, and the steel rail output will probably year by year take a less and less proportion of the total steel production.

The production of pig iron in the South, of which we have heard so much lately, showed a considerable increase, having been 744,619 tons in the first half of 1889 against 647,006 in the first half of last year. This increase was almost entirely in Alabama, the other iron-producing States of the South—with the exception of West Virginia, whose output is only about one-tenth of the whole—showing either very slight gains or an actual decrease. The total Southern production in the first half of this year was about 18 per cent. of the entire production of the country, so that it is already becoming a considerable factor in the trade, and, perhaps, has more effect than its actual amount would indicate from the fact that, in Alabama especially, Southern iron can be more cheaply produced than it can be anywhere at the North.

What has been said above in relation to the demand for and the uses of iron is supported by the fact that the increase last year was chiefly in those kinds of pig iron which are used for general foundry and mill purposes, and not in the iron used in the manufacture of steel, or Bessemer pig as it is generally called. Some complaint has been made by makers of the very low prices of iron, but the figures above given would seem to indicate that the iron trade is in a much better condition than many have anticipated.

In this connection we obtain from the same source the figures for an interesting comparison of the iron and steel production of the world, and its increase during the past 10 years. The table below gives, from the best available sources, the output of pig iron in 1878 and 1888 in the four leading iron-producing countries of the world; showing also the total estimated production of the world, and the percentage of that total, which each of the countries named produced:

	Production.		Percentage.	
	1888.	1878.	1888.	1878.
Great Britain	7,898,634	6,381,051	34.05	45.20
United States	6,489,738	2,301,215	27 98	16.30
Germany	4,258,471	2,147,641	18.36	15.21
France	1,688,976	1,417,072	7.28	10.04
World, total	23,194,475	14,117,902	....	....

The total production of steel is shown in the same way in the table below:

	Production.		Percentage.	
	1888.	1878.	1888.	1878.
Great Britain	3,405,536	1,100,000	35.18	36.41
United States	2,899,440	731,976	29.95	24.23
Germany	1,785,354	570,328	18.45	18.88
France	595,646	281,800	5.43	9.33
World, total	9,679,979	3,021,093	....	....

These two tables show in a very striking way the great increase in the production of iron and steel in the past 10 years, and show also the changes which have taken place. Great Britain, which 10 years ago turned out very nearly half the world's supply of iron, now produces only a little over one-third, while the proportion of the United States has risen from one-sixth to two-sevenths.

In steel the changes in proportion of the different producing nations have been much less, but the increase has been greater in proportion than in iron; while the total output of iron has risen only from 14,000,000 to 23,000,000 tons—although that is a sufficiently striking growth—yet the steel production of 1888 was considerably more than three times that of 1878. Much of this great increase is doubtless due to the invention of Bessemer steel, which has so generally taken the place of the better grades of iron in all sorts of construction.

It remains also to be added that the iron and steel industries everywhere in the world almost are showing continual gains, and that the use of both metals in construction is every year becoming more general, until they promise to replace almost entirely the inferior materials heretofore employed.

THE EXPOSITION OF 1892.

THE idea that the United States shall in 1892 commemorate the quarto-centennial of the great discovery of Columbus, by inviting the Old World to meet on the soil of the new continent with those of her children who have found a home there, and compare with them the progress which each has made, seems to have crystallized into the definite project of an universal exposition.

It is in New York that the project has become thus definite. When it was first vaguely talked of there were claims made by other centers of trade and population. Not without some show of reason some of the Western cities contended that, as the latest outcome of the new civilization, divested of all Old World traditions, they would present to all those who came to join in the celebration the clearest and most definite view of the New World under its present conditions. But they will, no doubt, gracefully yield, and tender their cordial co-operation to New York, when the whole question is more carefully considered and they review the many reasons why that particular point is the proper one.

The Government of the United States as the mouthpiece of the whole people must, of course, issue the invitations to the world, and it will be a courtesy from the whole people that its guests shall be asked and their entertainments prepared at the point most accessible to them. To all of them it is known that this point is only the gateway to the great civilization beyond, which they will be anxious to see, and most of them to study, and very few will be content to leave without seeing and studying the different parts of the country which their special business or predilections make most interesting to each.

Nor will it be forgotten that upon any community which assumes the charge of such an exposition a very grave and heavy responsibility will rest. It is not alone the glory and profit which are to be considered, for in this, as in every endeavor to earn either, we all know by hard experience that there is a vast amount of labor, of thought, and anxiety to be expended, and much of censure and criticism to be incurred, whatever may be the success attained.

The time for preparation, taking into account the work to be accomplished, is very limited, more especially when it is to be conducted by a popular movement and controlled and directed largely by men who have other and often pressing business calling for their constant attention, in this differing materially from those occasions in other countries in which the Government is the controlling and directing power.

In speaking and thinking of 1892, it seems to most of us a long time to look forward, the very change in the decade giving it a further futurity; but when we consider how much must be accomplished in two years and a half in

order to be ready for the exposition, the time will be found all too short for the work in hand.

While the necessary financial guarantees are a preliminary step of the first importance, they are outside of the questions to be here considered, and are in competent hands, and will, no doubt, be capably dealt with, though, in coming down to a consideration of their magnitude, much of the airy discussion respecting the claims of various geographical points fails to find a hearing, as it is realized that the people will require the exposition to be a commemoration of which they may be proud and which will be worthy both of the occasion and of themselves.

Although we have before us the examples and experiences of previous exhibitions in Europe, and of our own Centennial, it is the dominant feeling that we ought not to be satisfied with a mere imitation of these, with immense ranges of buildings of more or less architectural beauty and illustrative of engineering skill in construction, but that our engineers and architects shall devise an harmonious plan superior to any which has heretofore been presented—one which in itself will illustrate, or, as it might be said, graphically describe, the advances they have made in the various departments of the arts which they control. It is only those who are practically engaged in such work who know that it is not by a flash of intuitive genius that this is accomplished, but by careful, patient, and often long study, by much thought, and by a bringing together and blending of many opinions and intelligences, divergent in their modes of thought and action, and often actually hostile to each other, at least in the first development of their plans.

That beyond the first practical question of finance, the success of the exposition as an exponent of the great Western civilization will rest largely in the hands of the engineers of the country, who have done so much to build it up to its present proportions, is certain. It is hoped that it may not fail to meet with a responsive interest among them in all parts of the country through which they are scattered—not only from individuals, but from their several associations; and that such co-operation on their part may produce in 1892, not one engineering work dominating, in the popular estimation, all others, but a harmony in the whole idea and execution which shall illustrate the grand progress of every branch of the science here, and show what has been and is its co-operative work in the advancement of the civilization of the New World whose birth it will commemorate.

NEW PUBLICATIONS.

NOTES ON THE THEORY OF CANTILEVER BRIDGES: BY CHARLES MCMILLAN, C. E., PROFESSOR OF CIVIL ENGINEERING, PRINCETON COLLEGE. Octavo, paper, pp. 20, with 2 plates.

The theory of the computation of stresses in cantilever trusses is, of course, very simple to bridge engineers of experience, but to students special explanations are necessary. About one-half of this pamphlet is devoted to deducing the positions of the live load which give the greatest stresses in the various members of the truss, and the other half to a graphic method—using the equilibrium polygon—for finding the values of these stresses. The discussion includes the case of locomotive wheel loads; these are necessarily considered because often required by specifications, although, as the weights of locomotives are constantly changing, it appears to us to be a useless refinement. Professor McMillan's investigation is clear and concise and will doubtless prove valuable to those who study this important type of bridge.

THE LITERATURE OF GEODESY: COLLECTED BY DR. O. BOERSCH FOR THE INTERNATIONAL GEODETIC ASSOCIATION. Berlin; G. Reimer, 1889. Quarto, paper, pp. vii, 228.

The vast expanse of the literature of geodetic operations cannot be well appreciated without glancing over the titles of the books and memoirs to which alone 214 pages of this work are devoted. The arrangement is by countries, and it is gratifying to note that the United States ranks high in the character and number of works produced. Germany stands at the head with 60 pages of titles, France and Great Britain each have 24 pages, the United States has 21 pages, Russia 20 pages, Italy 15 pages, and eleven other countries have on the average about five pages each. A bibliographical work of this kind must prove of great assistance to students of geodesy.

BULLETIN NO. 9, U. S. COAST AND GEODETIC SURVEY: ON THE RELATION OF THE YARD TO THE METER: BY O. H. TITTMANN, ASSISTANT IN CHARGE OF WEIGHTS AND MEASURES. Washington; Government Printing Office. 6 pages.

Mr. Tittmann here discusses the work of various authorities who have compared the yard and the meter, and by referring all the observations to a common standard has succeeded in reconciling the discrepancies within very narrow limits. The following are his results for the number of inches in a meter according to the comparisons of the authorities named:

1817.	Hassler	39.36994 inches
1818.	Kater	39.36990 "
1835.	Baily	39.36973 "
1866.	Clarke	39.36970 "
1885.	Comstock	39.36984 "

The word inch here means one-thirty-sixth part of the British standard imperial yard, and the word meter means the length of an iron bar owned by the American Philosophical Society, which is usually called the "Committee Meter." This committee meter is the standard of metric measures used by the Coast and Geodetic Survey, but unfortunately its length is slightly different from that of the archive meter of Paris. The mean, of the above values is 39.36982 inches, which may now be taken as the probable mean value of the committee meter expressed in terms of the British standard imperial yard. If we understand correctly the remark of Mr. Tittmann concerning the archive meter, its probable length in terms of the same yard should be about 39.36983 inches.

THE DAFT SYSTEM OF ELECTRIC RAILROADS AND DISTRIBUTORY POWER PLANTS.

These are descriptive pamphlets of the systems of electric propulsion which the Daft Electric Light Company is introducing. They each give a brief history of the introduction and use of electricity, locomotion, and the distribution of power. The engravings are excellent and the printing superb. Their defect, however, which is common

to many trade catalogues, is that the writer has assumed that the reader knows much more about the subject treated of than is usually the case. If the author or authors had elucidated the subjects more fully, the pamphlets before us would have been much more interesting reading, and be a great deal more useful to the reader and to the Company which has issued them. Generally readers are fully as much or more interested in knowing how things are done as they are in what has been accomplished. The extent to which power is being distributed is, however, surprising many people, and the publication before us gives some very interesting information on this subject.

THE BERLIN IRON BRIDGE COMPANY: CATALOGUE, 1889. East Berlin, Conn.; published by the Company.

This catalogue contains a number of excellent engravings of bridges of different classes, truss, girder, and suspension, erected by this Company, and also of a number of iron roofs, bridges, and other structures. It has also an introduction intended to set forth the merits of the parabolic truss used by the Company in a large number of its bridges, giving the reasons why this truss should be preferred, and a short chapter on the relative economy of iron and wooden bridges for highway purposes.

The illustrations are all made from photographs and show a number of street and highway bridges of different spans and classes, and give a very fair idea of the great variety of work done by the Company.

HINTS ON HOUSE BUILDING: BY ROBERT GRIMSHAW, M.E.; published by the Practical Publishing Company, 21 Park Row, New York City.

This book consists of extracts mostly reprinted from the *Mechanical News*, and is published without any attempt at classification; but the Author, who is a practical engineer, has aimed to present hints on this important subject, which will be of use and interest to the public, and will stimulate readers to improve their present surroundings. Some of Mr. Grimshaw's hints are serviceable; with others many people will be inclined to find fault, but at any rate they are worth reading by those who intend to build.

BOOKS RECEIVED.

FIRST ANNUAL REPORT OF THE STATISTICS OF RAILROADS IN THE UNITED STATES TO THE INTERSTATE COMMERCE COMMISSION, FOR THE YEAR ENDING JUNE 30, 1888: HENRY C. ADAMS, STATISTICIAN TO THE COMMISSION. Washington, D. C.; Government Printing Office. Reference is made to this publication more at length in another column.

PRACTICAL BLACKSMITHING: A COLLECTION OF ARTICLES CONTRIBUTED BY SKILLED WORKMEN TO THE BLACKSMITH AND WHEELWRIGHT. COMPILED AND EDITED BY M. T. RICHARDSON. VOLUME I. New York; M. T. Richardson, 84 & 86 Reade Street (Price, $1).

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; issued by the Institution. The present installment includes Alternate-Current Machinery, by Gisbert Kapp, with an abstract of the discussion on the paper; Indian Railways, the Broad and Narrow Gauge Systems Compared, by Francis Waring, also with an abstract of discussion; the Tides in the Neighborhood of Portsmouth, by Bernard O'Driscoll Townsend; Tests of a Westinghouse Engine, by Stephen Alley; Steamers for Winter Navigation and Ice Breaking, by Robert Runeberg; Stress-Diagrams of Solid Structures, by Professor Robert Henry Smith.

THE DISTRICT DISTRIBUTION OF STEAM IN THE UNITED STATES: BY CHARLES E. EMERY, OF NEW YORK. London, England. Published by the Institution of Civil Engineers. This is a paper read by Mr. Emery before the Institution of Civil Engineers, and is accompanied by an abstract of the discussion on the paper.

HERZOGLICHE TECHNISCHE HOCHSCHULE CAROLO-WILHELMINA ZU BRAUNSCHWEIG: PROGRAM FÜR DAS STUDIENJAHR 1889–1890. Braunschweig, Germany. This is a programme of the course of studies pursued at the Ducal High School of Braunschweig, Germany, a technical school which has an excellent reputation on account of the thoroughness of its courses and the high professional standing of many of its Professors.

CORNELL UNIVERSITY, COLLEGE OF AGRICULTURE: BULLETIN OF THE AGRICULTURAL EXPERIMENT STATION, JULY, 1889. Ithaca, N. Y.; published by the University.

THE SEVENTEENTH ANNUAL REPORT OF THE PENNSYLVANIA COMPANY, FOR THE YEAR ENDING DECEMBER 31, 1888. Pittsburgh, Pa.; issued by the Company.

THE WESTINGHOUSE AIR BRAKE COMPANY. SUPPLEMENT TO CATALOGUE. Pittsburgh, Pa.; published by the Company. This supplement to the catalogue has been issued by the Westinghouse Air Brake Company, and announces an important and considerable reduction—varying from 4 to 23 per cent.—in the prices of air-brake material.

THE AMERICAN ELECTRIC COMBINATION LOCK: DESCRIPTION. This is a description of an apparatus for electric signaling and other purposes, invented and patented by Mr. A. A. Hatch, of Kansas City, Mo., and includes some account of experiences had with it on various Western railroads.

THE WORTHINGTON HIGH DUTY PUMPING ENGINE AT THE UNIVERSAL EXPOSITION OF 1889: BY HENRY R. WORTHINGTON. New York, London, Berlin and Paris; Henry R. Worthington. This is a pamphlet descriptive of the Worthington Exhibit of pumps at Paris; it is fully illustrated, and the descriptive matter is in both French and English.

ILLUSTRATED CATALOGUE OF PERFORATED VENEER SEATINGS, CHAIRS, SETTEES, ETC. New York; Joel H. Woodman & Company.

POINTS ABOUT DRAWING INSTRUMENTS: BY THEODORE ALTENEDER. Philadelphia; published by the Author.

ELECTRICAL DISTRIBUTION OF LIGHT, HEAT, AND POWER: BY HAROLD P. BROWN, ELECTRICAL ENGINEER. New York; published by the Author.

WARNER AND SWASEY'S ILLUSTRATED CATALOGUE OF IRON AND BRASS-WORKING MACHINE TOOLS. Cleveland, O.; July, 1889.

ABOUT BOOKS AND PERIODICALS.

THE June number of the PUBLICATIONS of the American Statistical Association includes articles on American Railroad Statistics, by Professor Arthur T. Hadley, and on Statistics of Municipal Finance, by Professor Henry B. Gardner, with the usual book notices and other miscellaneous articles. Professor Hadley's article is well worth reading, and emphasizes the fact to which we have heretofore called attention, the lack of complete and reliable railroad statistics in this country.

In HARPER'S WEEKLY for August 10 there is a timely article on Roads and Road-making, by Francis F. V. Greene, containing much practical information on the subject and well illustrated.

Among the recent publications of John Wiley & Sons, New York, are a text-book on the METHOD OF LEAST SQUARES, by

Professor Mansfield Merriman. The book is based on Professor Merriman's former work on the same subject, but is so enlarged and altered as to be practically a new treatise.

The electric article in SCRIBNER's for August is by President Morton, of the Stevens Institute, and is on the Electric Light, treating of its gradual evolution and its present standing as an important industry.

HIRAM MYRON BRITTON.

THE announcement in the daily papers of the death of the former President of the Master Mechanics' Association, which occurred at his home in Oswego, N. Y., on August 10, has been read with sincere sorrow by his many friends and acquaintances, who are to be found in all parts of this country. He was for many years a prominent railroad officer, but he was more generally known by reason of his connection with the Master Mechanics' Association, as its President for nearly ten years.

He was born at Littleton, Mass., November 30, 1831, and was therefore 58 years old at the time of his death. While he was quite young his parents moved to Concord, Mass. He entered the service of the Fitchburg Railroad about the year 1848. In 1851 he was advanced to the responsible position of a locomotive engineer, which he filled very creditably to himself and to the satisfaction of his employers, for about 10 years. In 1861 he was appointed Master Mechanic on that road, but in 1865 he resigned that position to accept a similar one on the Indianapolis, Cincinnati & Lafayette Railroad, with his office in Cincinnati. In June, 1868, a preliminary meeting of Railroad Master Mechanics was held in Dayton, O., and another one a few weeks later at Cleveland, " for the purpose of taking action to organize an Association of Master Mechanics." Mr. Britton was present at both of these meetings and acted as Secretary. On September 30 of the same year another meeting was held in Cleveland, and a permanent organization was then effected, and Mr. Britton was elected President. He held this office until 1877, when he resigned. In 1870 or 1871 he was appointed Superintendent of the White Water Valley Railroad, with his office still in Cincinnati. In 1876 he was offered the position of Superintendent of the Eastern division of the New York & New England Railroad. Like many another son of New England, the temptation of going back to his native hills was irresistible, and he accepted the appointment, making Boston his home. He held the place on this road until 1880 or 1881, and was then made Superintendent and Manager of the New York, Susquehanna & Western, with his office in New York City. In 1883 he was made General Manager of the Rome, Watertown & Ogdensburg Railroad, which position he held up to the date of his death, although for a year or more past he was unable to attend actively to the duties of the office. In the autumn of 1887 an accident occurred on the road which required his supervision in clearing it away. He exerted himself violently at the time, and being in a profuse perspiration contracted a very severe cold, which was the eventual cause of his death. When his health began to fail he made a journey to Europe, and came back apparently so much improved that he resumed his duties on the railroad. After a while new indications manifested themselves, showing that his strong physical constitution had been undermined. In last November he went to Europe a second time and spent the winter in the South of France, with the hope of restoring his shattered health. The hope was, however, a vain one, and he returned to his home a few months ago only to end his days there.

He was a man of striking personal appearance, with a physique which, in his prime, was often envied by those who were apparently of frailer structure. He was a man of great energy and decision of character, gifted with a wonderful memory, and a remarkable aptness of understanding quickly certain traits in the characters of those with whom he came in contact, and divining their motives of action. The success and growth of the Master Mechanics' Association was largely—it may be said chiefly—due to his zeal and skill in conducting its affairs. Some one remarked that as the presiding officer, he had undisciplined troops to command, and he seemed to have the capacity of getting the best available service out of them. His presence in the chair was a stimulant to those on the floor, which has sometimes been sadly missed since he laid down the gavel. He was an earnest member of the order of Masons, and took an active part in its proceedings. He was a genial friend and companion, and was intensely zealous in the interests of his employers. During his administration the stock of the Rome, Watertown & Ogdensburg Railroad advanced in value from 18 to above par.

He has left a widow, two brothers—Isaac, who is in the town of Britton, Dak., and Augustus W., who is in Richland, N. Y.—and three sisters, Mrs. Daniel R. Hartwell and Mrs. Otis Hoyt, of Elgin, Ill., and Mrs. Charles W. Rogers, of Waltham, Mass.

ELECTRIC MOTORS.

THE following statements, which give an excellent idea of the part which the electric motor can be made to perform in our industrial system, are published in the Boston *Journal of Commerce* as extracts from a letter written by Mr. F. L. Pope, of New York, the well-known electrical engineer:

One of the ablest modern writers on industrial questions lays down the proposition, that the limitations of the advantages derived from the use of any form of force for industrial purposes are fixed by the possibility of distributing the power cheaply and economically, and, furthermore, that of the two factors, the power to distribute cheaply is of far greater importance than the power to produce cheaply. In illustration of this proposition, consider the cheapest source of energy now known—namely, the power of falling water. It has not been found possible to effect the distribution of this form of power except over very limited areas, from which it follows that all the industrial benefits derived from water power have necessarily been concentrated in the immediate vicinity of the point of its origin, and hence, when such places have been conveniently situated in other respects, they have acquired great industrial and commercial importance. Such instances may be found at Lowell, Lawrence, Manchester, Fall River, Holyoke, etc.

On the other hand, there are instances of very extensive and valuable water powers which cannot commercially be utilized, by reason of their geographical or topographical situation, such, for example, as the water power at Falls Village, Conn., one of the finest in New England, which is practically unavailable because there is not level ground enough in the vicinity to afford sites for the necessary factory buildings, tenements, and adjuncts.

Scattered all over New England, and, in fact, most of the Atlantic States, are innumerable mill sites of from 50 to 1,000 H.P., many of which were improved in former days, but which are now lying idle and contributing nothing to the industrial wealth of the community, by reason of their remoteness from modern facilities of transportation and other inconveniences of their situation. Every horse-power of energy thus running to waste would be worth to the community from $50 to $100 per year, were it so situated as to be utilized to the best advantage.

It is manifestly an important part of the mission of modern electrical development to render all this waste power once more available for industrial purposes. Every increase in the limits of the economical distribution of power increases the opportunity for employment, adds to the ease, convenience, and comfort with which the artisan accomplishes his work, and enlarges the surplus wealth for the community.

The two countries which have made by far the greatest advances in the utilization and distribution of electric power are Switzerland and the United States. It is well known that Switzerland is disadvantageously situated as a manufacturing country, for the reason that, although it is supplied with an almost unlimited number of the finest

water powers in the world, situated upon unfailing streams fed by the melting of Alpine snows, yet these are located, in almost every instance, in inaccessible valleys and ravines, where economical transportation of heavy products is impossible. The railroad lines are situated in the main valleys at too great a distance from the water powers, in the majority of cases, to render them of much value. Steam power, on the other hand, is expensive, as there are no coal-mines in the republic, and the coal used must be brought many hundred miles and up heavy grades, which render it so costly that the Swiss manufacturers have been unable to compete successfully with those more favorably situated in countries in closer proximity to the iron and coal districts. The manufactures of Switzerland have, for this reason, heretofore been confined to the lighter and more delicate varieties of machinery, in which the cost of labor is the principal element and the cost of transportation an inconsiderable one.

The recent introduction of methods of transporting and distributing power by electricity is rapidly changing this state of affairs, and in a few years it is probable that Switzerland will become one of the foremost manufacturing countries of Europe in all those varieties of industry in which cheap power is an important element, such as the manufacture of steam-engines, locomotives, and heavy machinery, of paper, cotton and woolen goods, and the like.

In the ancient city of Solothurn, in the northwestern part of Switzerland, there is a manufactory of machine screws which is driven by an electric motor of 50 H.P., which derives its energy from a turbine wheel which is situated on a mountain stream at a distance of over five miles from the works. The electric current is conveyed upon wires not larger than an ordinary lead-pencil, suspended upon poles on the public highway. No one would notice any difference between this line and the ordinary telegraph line, and, in fact, there is no difference, except that the construction is rather more substantial and the insulation more carefully attended to. The proprietor of this factory informed Mr. Pope that his electric motor had been running 11 hours a day for over two years and had never been out of order for a moment, and had required no repairs; he could not say too much in its praise.

The same gentleman also visited a delaine mill at Derendingen, Switzerland, of 36,000 spindles and the necessary complement of other machinery. This factory was driven by a pair of electric motors of 280 H.P., deriving their energy from a turbine wheel situated about 1½ miles from the factory, the connection being made by a line of insulated copper wire similar to the one at Solothurn. The manager of this factory told exactly the same story. He had never had any trouble whatever with the motors, that had been running for a year without repairs, and appeared likely to run for an indefinite length of time. He considered it far superior to any other form of power, especially in the manufacture of the delicate white woolen goods, in which the absence of the smoke, cinders, and dirt from a steam-engine was a particularly desirable condition. This is also the case in paper-making and other industries of like character. The cost of this electric installation at Derendingen, including the electric generators, electric motors, and connecting conductors, was about $15,000 of our money, or about $54 per effective horse-power. The cost of attendants, repairs, and maintenance is trifling.

There are several other instances of electric power transmission in Switzerland. One of these, at Lucerne, carries 120 H.P. half a mile, and another 250 H.P. a quarter of a mile. From what Mr. Pope saw, it was quite clear that there could be no possible difficulty in conveying even 1,000 H.P. at least a distance of five miles, and there is no reason to suppose that this distance is anywhere near the possible limit which may be attained.

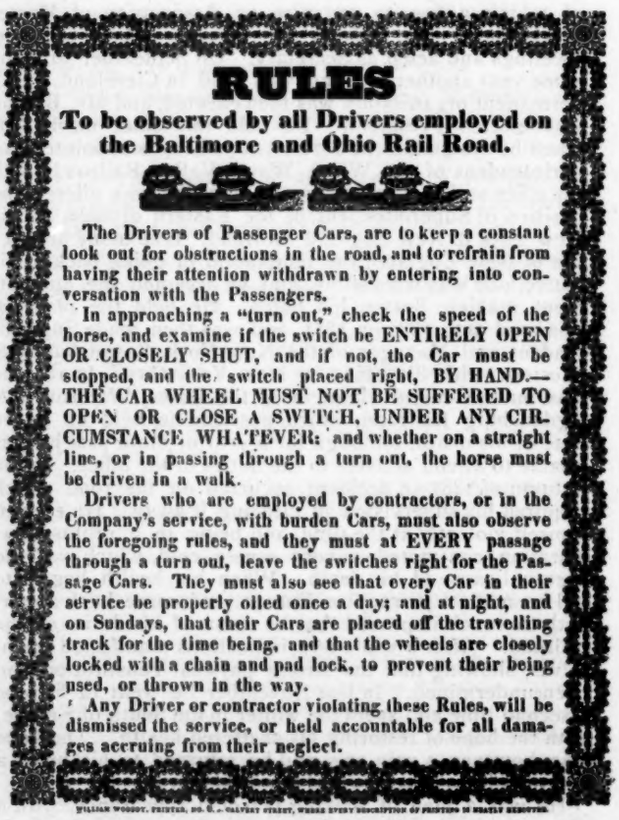
The installations described were put in by the Oerlikon Machine Company, whose works are near Zurich, and employ about 800 men. The visitor was informed that, in consequence of the success of the plants at Solothurn and elsewhere, their books were crowded with orders, and, especially, that they had received an order from Northern Italy for a much larger plant than any which had yet been erected.

We have no examples in the United States of anything like this amount of power being transmitted and utilized by a single motor. The writer says he does not know of any motor which has yet been set up of over 60 H.P. The development of power transmission in the United States has been mainly in the direction of distribution from a common source of energy to many small motors. Recent returns afford a basis for an approximate estimate that there are as many as 6,000 electric motors to-day in use in the United States, for industrial purposes. These have a capacity varying from the small one-sixteenth H.P. which is used to drive a family sewing-machine up to the 50 and 60 H. P. Motors employed in mining and milling works. One of the most common and favorite sizes is 10 H.P., of which large numbers are in use in New York, Boston, Baltimore, Rochester, and many other places.

Every manufactory of electric motors in the United States is crowded to its utmost capacity in its efforts to meet the constantly increasing demands for electric power. Mr. Pope thinks it is, apparently, only a question of time, and not a very long time, either, when it will be difficult to find in any city a steam-engine of less than 50 H.P. capacity, the demand for smaller powers being met so much more conveniently and economically by the electric motor.

THE BALTIMORE & OHIO RAILROAD IN THE OLDEN TIME.

THE following is a reduced copy of printed rules issued by the Baltimore & Ohio Railroad before the days of locomotives. The copy, which was found among some old



RULES

To be observed by all Drivers employed on the Baltimore and Ohio Rail Road.

The Drivers of Passenger Cars, are to keep a constant look out for obstructions in the road, and to refrain from having their attention withdrawn by entering into conversation with the Passengers.

In approaching a "turn out," check the speed of the horse, and examine if the switch be ENTIRELY OPEN OR CLOSELY SHUT, and if not, the Car must be stopped, and the switch placed right, BY HAND.—THE CAR WHEEL MUST NOT BE SUFFERED TO OPEN OR CLOSE A SWITCH, UNDER ANY CIRCUMSTANCE WHATEVER; and whether on a straight line, or in passing through a turn out, the horse must be driven in a walk.

Drivers who are employed by contractors, or in the Company's service, with burden Cars, must also observe the foregoing rules, and they must at EVERY passage through a turn out, leave the switches right for the Passage Cars. They must also see that every Car in their service be properly oiled once a day; and at night, and on Sundays, that their Cars are placed off the travelling track for the time being, and that the wheels are closely locked with a chain and pad lock, to prevent their being used, or thrown in the way.

Any Driver or contractor violating these Rules, will be dismissed the service, or held accountable for all damages accruing from their neglect.

WILLIAM WOODY, PRINTER, NO. 6 — CALVERT STREET, WHERE EVERY DESCRIPTION OF PRINTING IS NEATLY EXECUTED.

papers in the possession of Mr. Horatio Allen, is not dated, but it was among some other documents dated 1828, and probably the "Rules" were in force on the Baltimore & Ohio about that time. The copy we print has been reduced from the original somewhat more than half the linear scale.

THE DEVELOPMENT OF THE MODERN HIGH-POWER RIFLED CANNON.

By Lieutenant Joseph M. Califf, Third U. S. Artillery.

(*Continued from page 363.*)

Part III.—Modern Rifled Guns and Projectiles.

I.—RIFLED ORDNANCE.

The first decided step in the development of the heavy gun, as of the small-arm, was in converting it from a smooth-bore into a rifle.

The advantages of a rifled over a smooth-bored fire-arm are too well known to call for elaborate description. Briefly stated, these advantages may be summed up in the two qualities—greater range and greater accuracy. From a ballistic standpoint these two qualities cover about the whole field of efficiency of any arm, large or small. The greater range of a projectile implies the possession of superior living force, or stored-up energy or capacity for work; whether this energy is expended in overcoming the resistance of the air or in battering down a wall or in piercing armor is immaterial. Greater accuracy means, of course, the ability to do better and more reliable work, and is of scarcely less importance than the other.

Fig. 1. *Fig. 2.* *Fig. 3.*

Fig. 4. *Fig. 5.* *Fig. 6.* *Fig. 7.*

Even with spherical projectiles the advantage of giving them a rifle motion is pronounced, although far less than with those of elongated form. A spherical projectile, however carefully made, will never be perfectly homogeneous; the centres of figure and of inertia will never exactly coincide; there will always be certain inequalities upon the surface to offer unequal resistance to the air, hence the flight of a spherical projectile from a smooth-bore gun can never be accurately predicated. If, however, you give the same projectile a rapid rotary motion, it is easily seen that inequalities both of figure and surface are neutralized and the missile becomes practically homogeneous, to say nothing of the superior ability a body so circumstanced will possess for overcoming atmospheric resistance.

But the great advantage a rifle possesses over a smooth-bore gun lies in the fact that it enables us to employ other than spherical projectiles. With projectiles of the same caliber, or which will offer the same cross-sectional area to the resistance of the air, we can, by giving them an elongated form, obtain from three to five times the weight of metal. This implies an enormously increased ability to overcome the resistance of the air, or to do other work. Another advantage is that we can give to the head of our projectile such a shape as will offer the least resistance to this atmospheric retardation.

Efforts innumerable have been made to employ oblong projectiles in smooth-bore guns. The resistance of the air, acting as it does upon the head of a projectile, while the center of inertia is well to the rear, will invariably cause it to turn end for end, or revolve about its shorter axis, unless some force more powerful can be brought to bear to overcome this inclination. If it were possible to concentrate the weight of the metal at the point of a projectile there would, of course, be no tendency to "tumble." As this is practically impossible, stability must be secured in one of two ways—either by giving the projectile a rotary motion about its longer axis sufficiently strong to overcome this tendency, or by giving it some peculiar shape, so that the action of the air may itself keep it true in its flight.

Rotary motion may be imparted to a projectile thrown from a smooth-bore gun (1), by the action of the powder gas upon the shot inside the bore, or (2) by the pressure of the air upon the projectile after it has left the bore. The scores of models in our Patent Office provided with spiral flanges, or spiral grooves cut upon the exterior or running through the metal of the projectile, show how persistent has been the effort in this direction. To obtain steadiness of flight without a resort to rotary motion, wings, straight grooves, and flanges of various shapes have been employed, with the expectation that the pressure of the air upon the sides or along the grooves would be sufficient to keep the projectile head on. Many experiments have been tried with these various projectiles, but no satisfactory results have ever been obtained.

In rifled guns rotary motion is imparted to the projectile in but one way, that by some mechanical means inside the bore of the gun. The various methods employed to attain this end are called systems of rifling. The degree of twist given to the grooves and the length and form of the projectile depend upon the work to be required of the gun rather than upon the system upon which it may be rifled.

Four different systems of rifling have at different times been employed: (1) by giving a peculiar form to the bore of the gun itself, as that of a twisted ellipse or hexagon, with projectiles of corresponding shape; (2) by means of two or more deep grooves, with projectiles having corresponding studs or ribs to fit; (3) by means of numerous shallow grooves, and providing the projectile with a soft metal cap or envelope which is expanded into the grooves by the powder gas, used only in muzzle-loading guns; and (4) breech-loading guns with shallow grooves, with projectiles having a soft metal band or coating somewhat larger than the diameter of the bore, into which it is compressed by the powder gas. The first and second systems are suitable for either breech or muzzle-loading guns.

The "twist" which it is necessary to give to a projectile in order to maintain its stability, or the velocity of rotation, as it is called, will vary with its caliber and initial velocity, as well as with the shape, the density and the position of its center of gravity. The higher the initial velocity the greater will be the resistance of the air, and the greater the inclination to tumble; hence, if you increase the velocity, other things being equal, the twist of your

rifling must be correspondingly increased. Again, a long projectile will require a sharper twist than a shorter one; a light projectile than a heavier one of the same caliber. There is, therefore, no general rule that can be laid down as governing the proper twist for a rifle. It must be decided by the caliber of the piece and the work it will have to do.

The measure of this twist will be the length of one complete revolution of the spiral. This is usually measured in terms of the diameter of the bore. Some of the earlier cannon had a twist of one turn in 65 calibers, while some of the later systems reduce it to but little more than a third of this figure. In nearly all the earlier systems the twist was uniform, but at the present date an increasing twist has been almost universally adopted. It has the advantage of relieving the chamber of the piece from some extra strain during the first instants of the combustion of the charge.

The development of a uniform groove would be the diagonal of a rectangle, whose base is the circumference of the bore. A variable groove would be obtained by following the line of an arc of a circle wrapped around the surface of the bore. The curve used in both our new Army and Navy guns is that of a semi-cubical parabola. The same curve is also employed in some foreign systems of rifling.

Fig. 8.

Fig. 9.

Fig. 10.

The first rifled cannon, that of Major Cavalli, referred to in a previous article, was rifled with his deep grooves, with corresponding projections upon the projectile, as shown in fig. 1. This was improved upon by Captain Gillion, of the Belgian Artillery, who substituted four grooves and four projections for the two of Cavalli; this is shown in fig. 2. Another plan was proposed by an Italian officer, Saint Robert, which was novel in that by so arranging the metal in his projectile, which was hollow, he gave it a revolution about its shorter axis and parallel to the plane of fire, instead of perpendicular, the grooves being without twist, as shown in fig. 3.

The first rifle to receive actual test in war was the English Lancaster gun. The bore was elliptical in its cross-section, with a corresponding shape to the projectile. This is shown in fig. 4. The first guns of this system were rifled with an increasing twist, but owing to the proneness of the shot to jam, a uniform twist to the ellipse was afterward adopted, making one-quarter of a turn in the length of the bore. The system, however, did not survive the Crimean War. This belonged to the first system of rifling previously mentioned, as did also the Whitworth, which was developed about the same time.

In the Whitworth system the bore is of the form of a spiral, or twisted hexagon, fig. 5. This system of rifling is still adhered to in all Whitworth guns. The projectiles are made without studs or coating and are turned accurately to correspond with the bore. The rear portion is tapering, thus giving a bearing surface of about half the length. Guns rifled upon this system have the advantage of imparting the rotary motion to their projectiles, with a certainty not always attained in any other system.

The earlier French and the Woolwich systems of rifling belong, as do those first mentioned, to the second class. In the French system there were six spiral grooves in the bore of the gun, and the projectile had six corresponding rows of zinc studs, two in each row, as shown in fig. 6. The Woolwich system was almost identical with the French, except that the grooves in the bore were three or more, corresponding to the caliber of the gun.

In the Austrian service of this date, which was that of 20 years ago, the grooves were saw-shaped, the projectiles having soft metal ribs to fit the grooves; this is shown in fig. 7.

In the Prussian system, which belonged to the third class, the grooves were numerous and wider at the bottom of the bore than at the muzzle. The body of the projectile was cast with under-cut projecting wings, over which was cast a coating of lead. When the shot was driven toward the muzzle on discharge the soft coating was forced into the grooves, or *stagged*, as it is called, and gave to it a rotary motion corresponding to the twist, which in this system was one turn in fifty calibers. This system is shown in fig. 8.

To secure greater accuracy various methods have been devised to *center* the projectile—that is, to cause it to leave the bore with its axis perfectly true with that of the bore. The Armstrong *shunt* system is the one of this character best known. In it the grooves at the muzzle are double, the half on the right, or driving side, being comparatively shallow, an incline leading from the deep to the shallow part. The projectile was provided with copper studs which, when it passed down the bore from the muzzle, followed the deeper half. When, however, the projectile was driven out, the studs following up the incline were forced into the shallower half, compressed and the projectile accurately centered, as indicated in fig. 8½.

With muzzle-loading rifles the method almost universally employed is to provide the shot with a cup or band of soft metal, usually copper or brass. This is forced by the action of the powder gas into the grooves, which are more numerous and shallow than in the stud or rib systems. In the United States this has been the only system followed. The Parrott rifles had from 9 to 15 grooves, according to caliber, 0.1 inch deep and with an increasing twist. The projectiles were provided with a narrow ring of brass, flush with the base of the shot, which was forced outward on discharge. The Butler sabot is the one now most used.

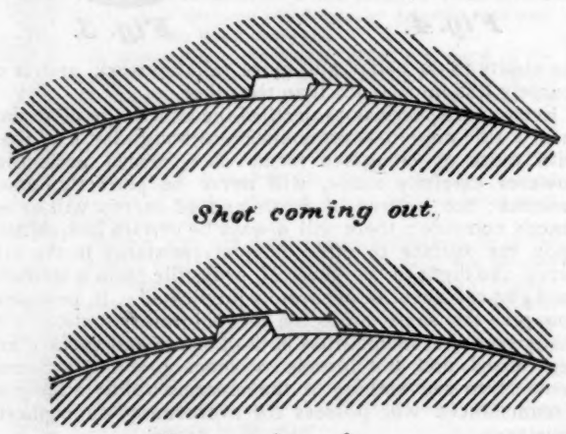


Fig. 8½

It consists of a bronze ring screwed upon the base of the projectile. An annular groove is cut in this ring, in which the powder gases act to force the exterior rim into the grooves. This is shown in fig. 11. The Eureka sabot is also in use in our service. Its construction is shown in fig. 12.

Following the general introduction of breech-loading ordnance a change in the systems of rifling, or rather in the methods employed for giving rotation to the projectile followed. Under what is classed as the fourth, or breech-loading, system, the grooves of the gun are numerous and shallow; the projectile has soft metal bands or coating of a slightly greater diameter than the bore. The disadvantages of using a lead coating for projectiles, which was at one time extensively done, were so great that it has now been entirely abandoned, and the use of one or two bands of soft metal has become universal.

Where two bands are employed the front one has a diameter equal to that across the bands, and acts simply as a centering band, while rotation is communicated by the band at the bore. In the French service the front band is replaced by a slight swelling of the metal of the projectile. Fig. 13 shows the rotation band of our 8-in. Army rifle projectile; in this case a battering or armor-piercing

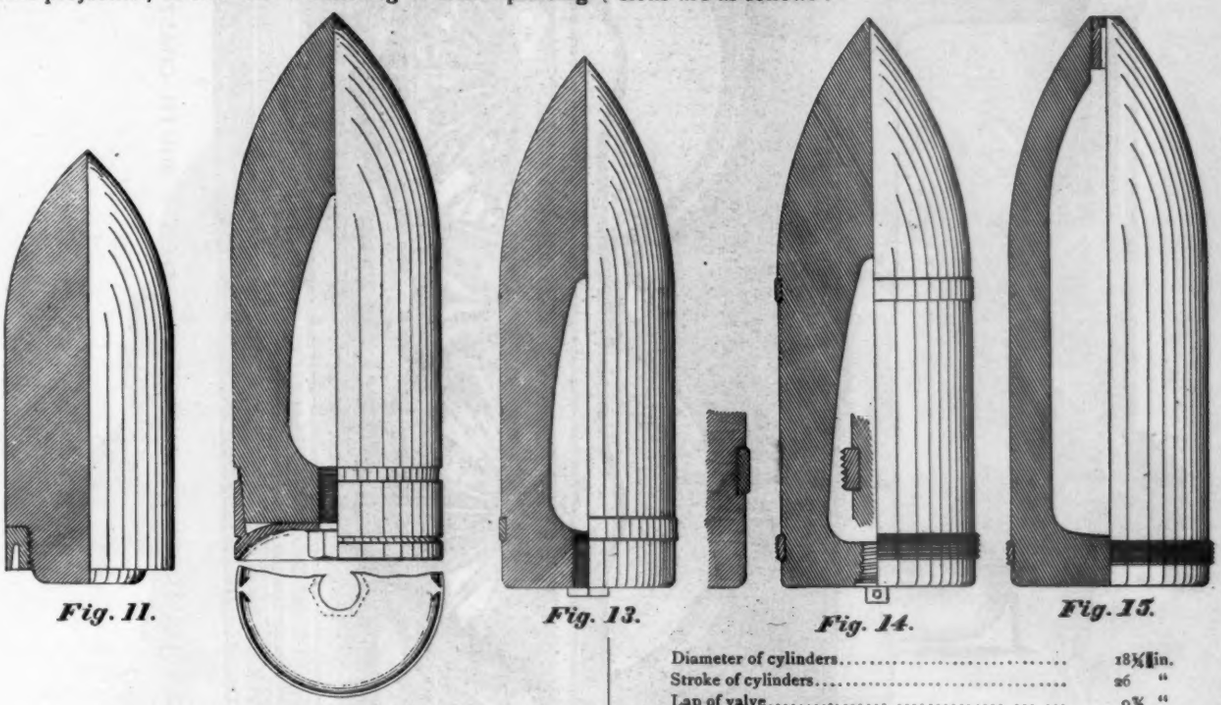


Fig. 11. *Fig. 12.* *Fig. 13.* *Fig. 14.* *Fig. 15.*

shell. The band is of soft copper, and as shown is forced into an undercut groove. The band is prevented from slipping by depressions or cups cut at intervals along the inner surface of this groove. Figs. 14 and 15 show two Krupp projectiles, the former, the battering shell, provided with two bands; the forward one being simply a centering band. The rear band is serrated to facilitate its taking hold of the grooves. The latter is the common shell, and has but the single rotation band.

The 110-ton Elswick gun is poly-grooved, with an increasing twist, beginning at the breech, with one turn in 120 calibers, and ending at the muzzle with one turn in 56 calibers. All the recent models of German (Krupp) guns have the increasing twist. The 119-ton Krupp has 92 bands and grooves. Our 8-in. Army rifle has 45 bands and grooves, with a pitch at the origin of one turn in 70 calibers, which increases to one in 25 calibers up to within 16 in. of the muzzle, where it becomes uniform. This is shown in fig. 9. The 8-in. Navy rifle has 12 peculiar-shaped grooves, which increase from zero at the origin to one turn in 25 calibers at the muzzle; this is indicated in fig. 10.

(TO BE CONTINUED.)

AN ENGLISH EXPRESS ENGINE.

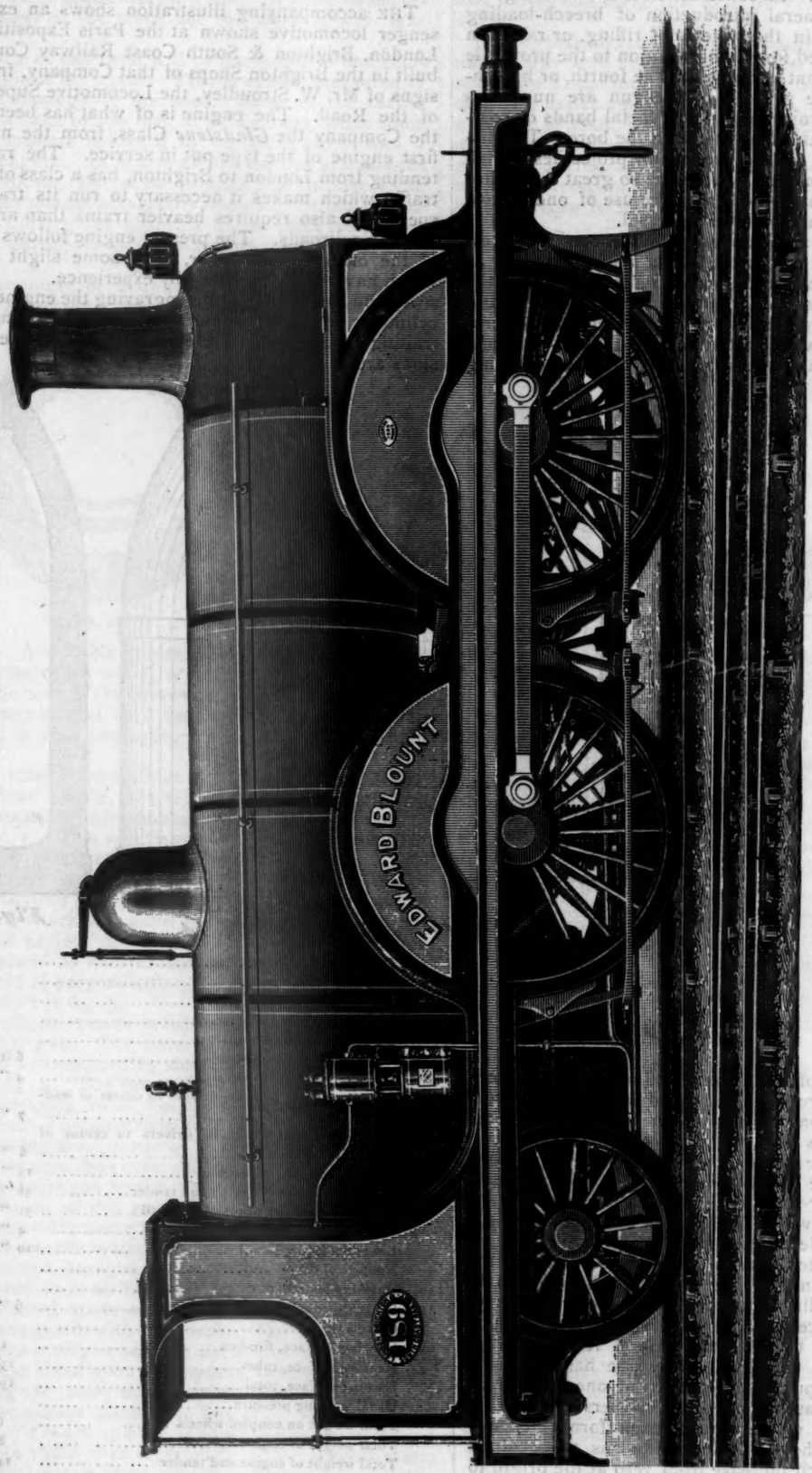
(From the London *Engineer*.)

THE accompanying illustration shows an express passenger locomotive shown at the Paris Exposition, by the London, Brighton & South Coast Railway Company and built in the Brighton Shops of that Company, from the designs of Mr. W. Stroudley, the Locomotive Superintendent of the Road. The engine is of what has been called by the Company the *Gladstone* Class, from the name of the first engine of the type put in service. The railroad, extending from London to Brighton, has a class of passenger traffic which makes it necessary to run its trains at high speed and also requires heavier trains than are usual on English railroads. The present engine follows the design of the original *Gladstone*, with some slight differences which have been suggested by experience.

As will be seen from the engraving the engine has inside cylinders and four coupled wheels, with a single pair of trailing wheels behind the fire-box. Its general dimensions are as follows:

Diameter of cylinders	18½ in.
Stroke of cylinders	26 "
Lap of valve	0⅞ "
Lead of valve, in full gear	0⅛ "
Distance of cylinders apart	25 "
Diameter of driving-wheels	6 ft. 6 "
Diameter of trailing-wheels	4 " 6 "
Distance, center of main drivers to center of leading-wheels	7 " 7 "
Distance, center of main drivers to center of trailing-wheels	8 " 0 "
Total wheel-base of engine	15 " 7 "
Total wheel-base of engine and tender	38 " 9½ "
Length of engine and tender over all	51 " 10 "
Mean diameter of boiler barrel	4 " 5 "
Length of boiler barrel	10 " 2 "
Number of tubes	333
Outside diameter of tubes	1½ "
Length of fire-box, outside	6 " 8¼ "
Grate area	21 sq. ft.
Heating surface, fire-box	114 " "
Heating surface, tubes	1386 " "
Heating surface, total	1500 " "
Usual working pressure	150 lbs.
Total weight on coupled wheels	63,450 "
Total weight of engine	86,700 "
Total weight of engine and tender	147,850 "
Water capacity of tender tank	2,250 gals.

It is further stated that the average temperature of the feed-water in actual service is 145°, and the average quan-

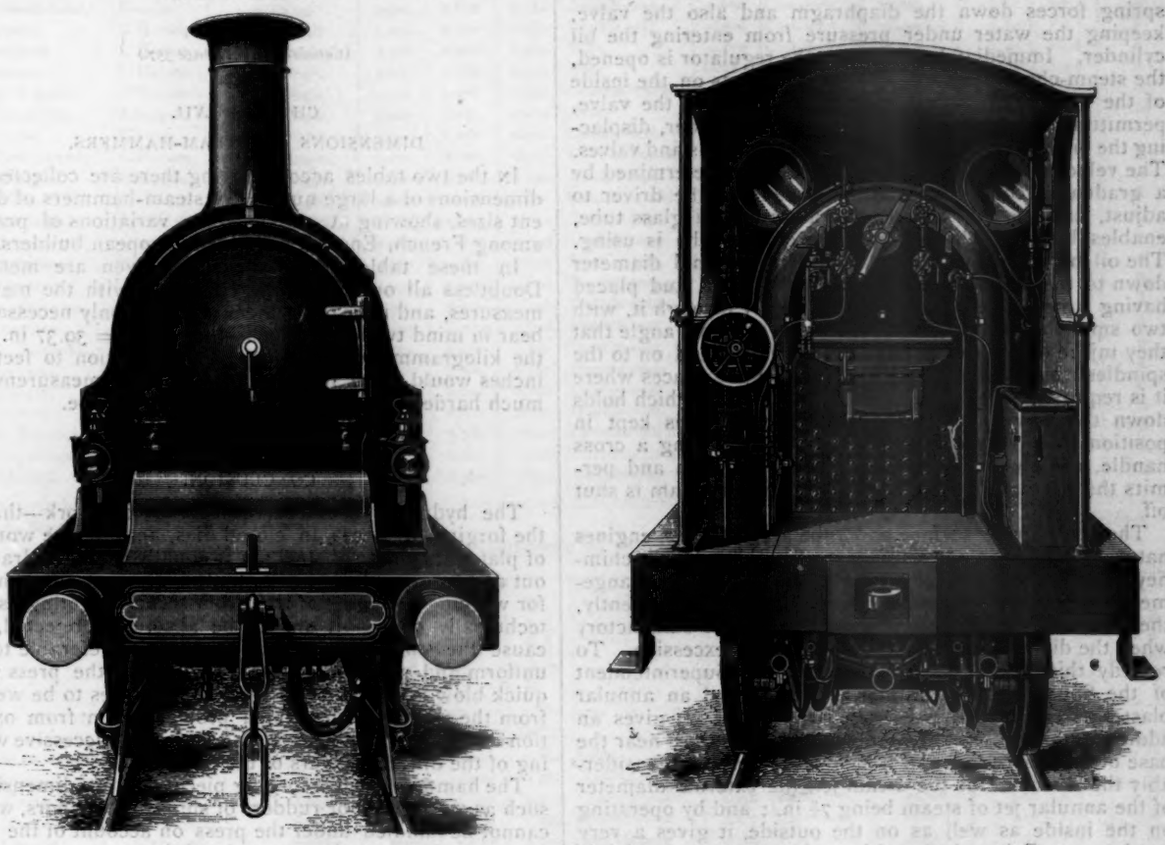


EXPRESS PASSENGER LOCOMOTIVE, LONDON, BRIGHTON & SOUTH COAST RAILWAY.

tity of water evaporated per pound of coal is 12 lbs. The maximum schedule time of the trains, on which this engine is run, is 46¼ miles an hour, and the longest run without stop is 86 miles. The maximum number of carriages hauled is 26, and in this case the total weight of the train, including the engine, is 378 tons. The average coal consumption of 18 engines of this class was 28 lbs. per mile run.

Of the changes made from the original pattern in the present engine, the most important one is in the steam-chest. Mr. Stroudley considered it judicious to increase the width of the steam ports from 15 in. to 16 in., and the length from 1⅛ in. to 1½ in.; This is to enable the engine to get rid of the steam more freely with very heavy loads. In doing this he has removed the sides of the steam-chest altogether, and has left the valve faces on the same plane as the steam-chest cover joint; the steam-chest cover itself being made of semi-circular form, having the stuffing-box for the valve spindles cast in it, so that when the steam-chest cover is taken off, the slide-valves, spindles, etc., are removed *en masse*, the joint remaining, however, of the same size as in the earlier engines. This reduces the cylinder casting, cheapens the construction, and offers a great number of facilities for handling. He has also provided the slide valves with three relieving rings on the back; these take away the major portion of the steam pressure from the valve faces. The valves themselves are carried on a slipper, which travels along with the valve and supports the same by means of four spiral springs. The slipper has three holes in the back, through which the relieving rings pass to work in contact with the face cast in the steam-chest cover, which has three small holes connecting the rings with the open air. The valve spindles are let into the intermediate link with a cone, fastened with a cotter in the usual way; but there is a hole drilled beyond the end of the cone, through which a taper pin can be driven to start the valve spindle after the cotter is taken out, rendering the disconnection of this detail very simple. The intermediate link is made separate from the guide and is attached to it by a nut, having a washer ¼ in. thick placed so as to permit any slight adjustment that may be required in the length of the valve spindle, as this washer can readily be turned to the exact thickness necessary. This renders the setting of the valves extremely easy.

The next alteration is in the reversing gear. The air cylinder for lifting the motion into back gear, instead of having a large balance weight as usual, works admirably. It was necessary, however, to have a circular rack fixed upon the screw, with a detent to retain it in position; and there was in addition a pinching screw to nip the nut solid to the guide when the engine was in motion, to prevent the chattering which takes place by the varying angle of the expansion link. This acts perfectly if the driver will use it; but it very often happens that he allows the engine to run held by the circular rack only; and this chatters away the thread of the reversing screw and nut. So Mr. Stroudley decided to put an air-brake to hold this, instead of the catches or pinching screws; and he makes a rectangular-shaped washer with rounded corners and fits this to the nut, inside of which is placed a cup leather. A bent steel pipe conducts the air from the main reservoir into this cup leather, which has a holding power of about two tons, and which is amply sufficient to hold the gear quite solid. The small three-way cock, which sufficed for the reversing gear previously used, has been removed, and a flat valve having a three-ported face, something similar to the one which he made for the Westinghouse brake, is arranged in its place. When the handle of this is put forward it exhausts the main reversing cylinder and at the same time slackens the nipping gear. When it is put backward it also slackens the nipping gear and turns the air in behind the reversing piston, so as to bring the engine into back gear if necessary. When the handle of this valve is placed in the middle position it locks this gear at whatever point the driver may determine, and as there is no catch or other means of holding the reversing gear in position, it becomes absolutely necessary for the driver to lock it. Mr. Stroudley has no doubt, from the experience he has had, that this will be a vast improvement on anything of the kind which has hitherto been adopted, and will save a lot of wear and tear.



EXPRESS LOCOMOTIVE, LONDON BRIGHTON & SOUTH COAST RAILWAY.

The difficulty of properly lubricating the slide-valves and pistons of locomotives has been felt by all connected with them, and Mr. Stroudley designed a lubricator which operates as a sight-feed lubricator, but is actuated by steam pressure taken direct from the boiler. It is automatic, but it can by a touch of the handle be used to let in oil when the engine is running down a bank with the steam shut off, when other lubricators will not act. The principle of the construction is a chamber filled with oil, and connected with a small steam pipe from the gauge fittings; this is passed into a larger pipe, which condenses water, which is forced by the whole pressure of the boiler into the bottom of the oil cylinder. The opening into the oil cylinder is, however, closed by a valve, which is pressed down by a strong spiral spring, and between the top end of this valve-spindle and spiral spring an elastic metal diaphragm is placed. So long as the steam is shut off the spiral spring forces down the diaphragm and also the valve, keeping the water under pressure from entering the oil cylinder. Immediately, however, the regulator is opened, the steam-chest pressure passes up and acts on the inside of the diaphragm lifting it up and also lifting the valve, permitting the water to pass into the oil cylinder, displacing the oil, which is passed along to the pistons and valves. The velocity with which this can operate is determined by a graduated cock conveniently placed for the driver to adjust, and the oil, passing down through a glass tube, enables him to judge exactly the quantity he is using. The oil passes along a pipe about $\frac{5}{8}$ in. internal diameter down to the steam-chest, in which there is a stud placed having a main central hole drilled nearly through it, with two small holes drilled in the end at such an angle that they inject oil on to the faces of the valves and on to the spindles, thus applying the lubricant in the places where it is required. The spiral spring referred to, which holds down the valve against the boiler pressure, is kept in position by a very quick-threaded screw having a cross handle, and a very slight turn relieves the action and permits the oil to pass into the cylinders when steam is shut off.

The large grate surface and tube area of these engines naturally requires a powerful blast. To obtain this the chimney has to be made larger, as from the structural arrangements of the line it cannot be made higher; consequently, the action of an ordinary blast-pipe is not satisfactory when the diameter of the chimney becomes excessive. To remedy this, Mr. W. Adams, Locomotive Superintendent of the Southwestern Railway, has designed an annular blast-pipe which possesses two advantages. It gives an additional outlet for the gases in the smoke-box near the base of the blast-pipe, and it also increases very considerably the diameter of the steam jet, the external diameter of the annular jet of steam being $7\frac{5}{8}$ in.; and by operating on the inside as well as on the outside, it gives a very much more efficient draft, without that sharpness which is induced by a small diameter of chimney and a solid jet of steam. A large number of these blast-pipes have been fitted on the Brighton Railway, and they are found to work very efficiently, the engine maintaining a full head of steam with the greatest ease.

It will be remembered that when the *Gladstone* was put to work, its safety-valves were loaded to 140 lbs. The *Gladstone* boiler, in common with all the boilers on this line made from Mr. Stroudley's design, was originally constructed to carry 150 lbs. pressure, and this is the standard pressure now adopted throughout the line in all the standard classes of engines.

With the load of 24 or 25 carriages which they have to run in the morning train from Brighton to London, and which has to do the 30 miles to Redhill in 40 minutes, notwithstanding that about 20 miles of the road is up gradients of 1:264, they require all the foothold that they can get; and after some considerable trouble Mr. Stroudley has adopted Messrs. Gresham & Craven's sanding apparatus, but, instead of turning on the steam to the sanding apparatus with a separate handle, Mr. Stroudley has connected the steam supply with the steam-chest; so that the driver can turn the handle for the sand into the proper position before he meddles with the regulator in starting; and the application of the steam to the pistons to drive the train also applies the sand to give foothold. This arrangement was designed by Mr. Stroudley's principal foreman, Mr. Jeffrey, and it answers the purpose admirably. It is found that this class of engine can run the 5 P.M. London to Brighton—a little over 50 miles—train with 17 to 18 coaches in 62 minutes from starting until stopping in the station at Brighton; this train is allowed 65 minutes, and the drivers frequently have as many as 20 carriages on, and keep exact time.

NOTES ON STEAM HAMMERS.

By C. Chomienne, Engineer.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Concluded from page* 357.)

CHAPTER LVII.

DIMENSIONS OF STEAM-HAMMERS.

In the two tables accompanying there are collected the dimensions of a large number of steam-hammers of different sizes, showing at a glance the variations of practice among French, English and other European builders.

In these tables the dimensions given are metrical. Doubtless all our readers are familiar with the metrical measures, and in reading them it will be only necessary to bear in mind two dimensions—the meter = 39.37 in., and the kilogramme = 2.204 lbs. The reduction to feet and inches would have resulted in fractional measurements, much harder to note and remember than these.

CHAPTER LVIII.

CONCLUSION.

The hydraulic press serves best for die-work—that is, the forging of pieces in closed dies, and for the working of plates of iron or of steel; it is equally useful in drawing out and forging steel ingots, but for drawing out iron and for working up ingots of iron from scrap—fagoting as it is technically called—it should be absolutely rejected, because the sharp blow of the hammer is preferable to the uniform and more moderate pressure of the press; the quick blow is necessary to clear the surfaces to be welded from the slag or cinder which protects them from oxidation during the heating, and to secure the successive welding of the different layers of the pile.

The hammer permits forging pieces of large dimensions, such as stern-posts or rudders of ships and anchors, which cannot be handled under the press on account of the narrow space between the supporting columns.

We can always with a hammer, even of very great power, forge small pieces by simply reducing the stroke of the hammer and varying the dimensions of the hammer-head.

To speak in conclusion of local conditions, the valley of the Loire, and Rive-de-Gier in particular, have become the center of the most important forging industry of France. The forges of Petin-Gaudet, Arbel, Barrouin, Marrel Freres, Lacombe and others have made remarkable progress in this industry, in the same way as Brunon has done with work with the hydraulic press.

We have reached in France the point where the steam-hammer is most admirably managed, and where the smith uses his hammer to make the most delicate and the most difficult pieces.

It is sufficient for that purpose, as we have already said, to know how to proportion the intensity of the shock and the effect to be produced, and not to pass too abruptly from one form to another, but on the contrary to arrive gradually and almost insensibly and by successive heats to the form desired without injuring the structure of the metal. This it is which makes the art of the smith both slow and difficult to learn, and which proves once more the truth of the old proverb:

"It is by hammering that one becomes a Smith."

Table I.—Hammers of Less than 10 Tons.

	Place where used.	Builder of Hammer.	Single or Double Acting.	Weight of Working Parts.	Stroke of Hammer.	Diameter of Cylinder.	Kind of Valve used.	Diameter of Piston-rod.	Metal of Frame.	Total Weight of Anvil-block.	No. of Pieces.	Area of Base of Anvil-block.	Ratio of Weight of Hammer to Weight of Anvil.	Remarks.
				Kilogs.	Meters.	Meters.		Meters.		Kilogs.		Sq. m.		
1	St. Nazaire.	L'Horme.	Single.	500	1.200	0.200	Slide.	0.045	Cast-iron.	3,500	1	1.50	1:7	A
2	Ouvion.	L'Horme.	Single.	600	1 200	0.250	Slide.	0.045	Cast-iron.	4,800	1	2 00	1:8	A
3	Firminy.	L'Horme.	Single.	800	1.200	0.290	Slide.	0.080	Cast-iron.	5,200	1	2.00	1:6.5	A
4	Marseilles.	Forges & Chantiers.	Single.	1,000	1.000	0.315	Slide.	0.075	Cast-iron.	7,000	1	2.10	1:7	A
5	Marseilles.	Brunon.	Single.	1,000	1.000	0.320	Slide.	0.065	Cast-iron.	4,500	1	1.50	1:4.5	A
6	Marseilles.	Forges & Chantiers.	Single.	1,200	1.100	0.350	Slide.	0.075	Cast-iron.	6,000	1	1.60	1:5	A
7	Merardiere.	L'Horme.	Single.	1,200	1.200	0.330	Slide.	0.080	Cast-iron.	8,500	1	3.12	1:7	A
8	Izieux.	L'Horme.	Single.	1,500	1.500	0.360	Slide.	0.065	Cast-iron.	6,000	1	2.80	1:4	A
9	Marseilles.	Forges & Chantiers.	Single.	1 800	1.500	0.450	Slide.	0.095	Cast-iron.	6,000	1	2.00	1:3.3	B
10	Marseilles.	Forges & Chantiers.	Single.	2,000	1.500	0.450	Slide.	0.095	Cast-iron.	8,000	1	2.50	1:4	A
11	Marseilles.	Forges & Chantiers.	Single.	2,000	1.550	0.450	Slide.	0.050	Cast-iron.	14,000	1	3.06	1:7	A
12	Lorette.	L'Horme.	Single.	2,000	1.600	0.420	Slide.	0.080	Cast-iron.	10,000	1	3.18	1:5	A
13	Rive-de-Gier.	Brunon.	Single.	2,500	1.650	0.450	Double-seat.	0.090	Cast-iron.	15,000	1	2.80	1:6	A
14	Couzon.	L'Horme.	Single.	2,500	1.500	0.450	Double-seat.	0.090	Cast-iron.	10,000	1	3.20	1:4	A
15	Pompey.	L'Horme.	Single.	2,500	1.700	0.450	Slide.	0.100	Cast-iron.	12,000	1	3.25	1:4.8	A
16	Couzon.	L'Horme.	Single.	3,000	1.600	0.500	Slide.	0.120	Wro't-iron.	14,000	1	4.50	1:4.7	A
17	St. Nazaire.	L'Horme.	Single.	3,000	2.000	0.500	Circular-bal'd.	0.120	Cast-iron.	12,000	1	4.20	1:4	A
18	Marseilles.	Forges & Chantiers.	Single.	3,000	2.050	0.470	Slide.	0.110	Cast-iron.	27,365	1	4.46	1:9	A
19	Turin.	Bietrix.	Single.	3,500	2.000	0.500	Double-seat.	0.110	Cast-iron.	17,000	1	5.00	1:4.8	A
20	Niederbronn.	L'Horme.	Single.	3,500	2.000	0.550	Circular-bal'd.	0.140	Cast-iron.	15,000	1	4.20	1:4.3	A
21	Besseges.	Besseges.	Single.	4,000	2.500	0.650	Double-seat.	0.115	Cast-iron.	22,000	1	5.80	1:5.5	A
22	Firminy.	L'Horme.	Single.	4,000	2.000	0.600	Circular-bal'd.	0.160	Cast-iron.	40,000	1	6.30	1:10	A
23	Marseilles.	Forges & Chantiers.	Single.	4,000	1.800	0.550	Double-seat.	0.120	Cast-iron.	17,000	1	5.00	1:4.2	A
24	Creusot.	Creusot.	Single.	4,000	2.000	0 600	Double-seat.	0.125	Cast-iron.	21,500	1	5.00	1:5.3	A
25	St. Julien.	L'Horme.	Single.	5,000	2.200	0.650	Double-seat.	0.120	Cast-iron.	25,000	1	8.00	1:5	A
26	Guerigny.	Fives-Lille.	Single.	5,000	2 000	0 600	Double-seat.	0.150	Wro't-iron.	35,000	1	7.20	1:7	B
27	St. Étienne.	Bietrix.	Single.	5,000	2.000	0.500	Double-seat.	0.125	Cast-iron.	21,000	1	6.00	1:4.2	A
28	Chambon.	Bietrix.	Single.	5,500	2.000	0.600	Double-seat.	0.130	Cast-iron.	22,000	1	6.00	1:4	A
29	St. Étienne.	Bietrix.	Single.	6,000	2.000	0.600	Double-seat.	0.145	Cast-iron.	30,000	1	6 00	1:5	B
30	Creusot.	Creusot.	Single.	6,000	2.300	0.680	Double-seat.	0.140	Cast-iron.	35,000	1	7.00	1:5.8	A
31	Creusot.	Creusot.	Single.	6,000	2.300	0.700	Double-seat.	0.200	Cast-iron.	60,000	1	7.50	1:10	B
32	Creusot.	Creusot.	Single.	8,000	2.600	0.750	Double-seat.	0.160	Cast-iron.	45,000	1	9.00	1:5.6	A
33	St. Étienne.	Thwaites.	Double.	8,000	1.500	0.700	Circular-bal'd.	0.150	Wro't-iron.	40.000	2	9.00	1:5	B
34	Terrenoire.	L'Horme.	Single.	8 000	2.200	0.730	Circular-bal'd.	0.150	Cast-iron.	40,000	1	7.60	1:5	A
35	Firminy.	L'Horme.	Single.	8,000	2.500	0.850	Double-seat.	0.160	Cast-iron.	40,000	1	9.50	1:5	A

A. Frame rests on anvil-base. B. Independent anvil-block.

Table II.—Hammers of 10 Tons and Over.

	Place where used.	Builder of Hammer.	Single or Double Acting.	Weight of Working Parts.	Stroke of Hammer.	Diameter of Cylinder.	Kind of Valve used.	Diameter of Piston-rod.	Metal of Frame.	Total Weight of Anvil-block.	No. of Pieces.	Area of Base of Anvil-block.	Ratio of Weight of Hammer to Weight of Anvil.	Remarks.
				Kilogs.	Meters.	Meters.		Meters.		Kilogs.		Sq. m.		
35	Marseilles.	Forges & Chantiers.	Single.	10,000	2.200	0.830	Slide.	0.150	Cast-iron.	32,000	1	8.00	1:3.2	A
37	Marine.	Acieries.	Single.	10,000	3.000	0.870	Double-seat.	0 160	Wro't-iron.	55,000	1	7.50	1:5.5	A
38	Firminy.	L'Horme.	Single.	10,000	3.000	0.900	Circular-bal'd.	0.250	Cast-iron.	40,000	1	5.50	1:4	B
39	Niederbronn.	L'Horme.	Single.	10,000	3.200	0.850	Double-seat.	0.150	Cast-iron.	60,000	3	3.10	1:6	A
40	Couzon.	L'Horme.	Single.	10,000	1.600	0.850	Double-seat.	0.160	Wro't-iron.	40,000	2	7.30	1:4	B
41	Rive-de-Gier.	L'Horme.	Single.	12,000	2.200	0.900	Circular-bal'd.	0.180	Cast-iron.	41,000	1	8.20	1:2.9	A
42	Guerigny.	Creusot.	Single.	12,000	3.000	0.880	Double-seat.	0.196	Cast-iron.	90,000	4	13.00	1:7.5	A
43	Creusot.	Creusot.	Single.	15,000	2.850	0 950	Double-seat.	0.220	Cast-iron.	110,000	2	15 60	1:7.3	A
44	Lorette.	Bietrix.	Single.	15,000	1.600	0.820	Circular-bal'd.	0.180	Wro't-iron.	65,000	1	7 50	1:4.3	B
45	St. Étienne.	Acieries.	Single.	15,000	3.000	0.900	Double-seat.	0.190	Cast-iron.	55,000	1	6 co	1:3.7	B
46	Rive-de-Gier.	L'Horme.	Single.	20,000	3.000	1.100	Double-seat.	0 190	Cast-iron.	60 000	3	13.20	1:3	A
47	Guerigny.	Creusot.	Single.	20,000	3.000	1.450	Double-seat.	0.250	Cast-iron.	185,000	7	9.50	1:9.2	B
48	Couzon.	L'Horme.	Single.	20,000	1.600	1.000	Double-seat.	0.180	Wro't-iron.	60,000	2	8.20	1:3	B
49	Creusot.	Creusot.	Single.	20,000	2.850	0.950	Double-seat.	0.220	Cast-iron.	140,900	2	14.80	1:7	A
50	Sheffield.	Thwaites.	Double.	20,000	3.048	1.068	Circular-bal'd.	0.203	Wro't-iron.	203,210	5	21.00	1:10	B
51	Firminy.	L'Horme.	Single.	25,000	3.000	1.250	Double-seat.	0 220	Cast-iron.	100,000	2	12.30	1:4	B
52	Lorette.	Bietrix.	Single.	25,000	1.600	1.050	Circular-bal'd.	0.220	Wro't-iron.	95,000	1	11.00	1:3 8	B
53	Marine.	Acieries.	Single.	28,000	3.500	1 200	Double-seat.	0 210	Cast-iron.	75,000	1	13 00	1:3.6	A
54	Rive-de-Gier.	L'Horme.	Single.	30,000	2 000	1 320	Circular-bal'd.	0.220	Wood.	60,000	1	9.00	1:2	B
55	Elswick.	Thwaites.	Double.	30,000	3.660	1.200	Circular-bal'd.	0.254	Cast-iron.	304,000	4	16.00	1:10	B
56	Woolwich.	Nasmyth.	Double.	35,000	3 400	1.370	Circular-bal'd.	0.250	Cast-iron.	587,000	6	30.00	1:16	B
57	Marine.	Acieries.	Single.	35,000	3.500	1.350	Double-seat.	0.250	Cast-iron.	125,000	1	20 00	1:3.6	A
58	Couzon.	L'Horme.	Single.	40,000	1.600	1.320	Circular-bal'd.	0 240	Wro't-iron.	140,000	3	12.00	1:3.5	B
59	Creusot.	Creusot.	Single.	40,000	3.250	1 200	Double-seat.	0.250	Cast-iron.	210,000	3	17.80	1:5.3	A
60	Rive-de-Gier.	L'Horme.	Single.	50,000	4.0 0	1.480	Circular-bal'd.	0 260	Cast-iron.	250,000	4	14.40	1:5	A
61	Alexandrowski.	Thwaites.	Single.	50.000	3.800	2.000	Circular.	0.260	Cast-iron.	240,000	3	.....	1:4.8	B
62	Obookoff.	Thwaites.	Double.	50,000	4.572	1.981	Circular-bal'd.	0 305	Cast-iron.	508 485	8	48.00	1:10	B
63	Marine.	Acieries.	Single.	80 000	4.800	1.900	Double-seat.	0.340	Cast-iron.	500,000	5	25 00	1:6.3	B
64	Creusot.	Creusot.	Single.	100 000	5 000	1.900	Double-seat.	0.420	Cast-iron.	750,000	11	33.00	1:7.5	B
65	Terni.	Cockerill.	Single.	100,000	5.000	1.920	Double-seat.	0 360	Wro't-iron.	1,000,000	1	42.00	1:10	B
66	Rive-de-Gier.	Marrel Frères.	Single.	100,000	5.100	2 000	Circular-bal'd.	0 370	Wro't-iron.	500,000	7	28.62	1:5	B

A. Frame rests on anvil-base. B. Independent anvil-block,

NATIVE INDIAN SUSPENSION BRIDGES.

(From the *Indian Engineering.*)

THERE are still many good samples of primitive native suspension bridges in the Darjeeling District of Bengal. One of the largest and most characteristic of these structures is swung over a mountain torrent 300 ft. wide, at a height of 70 ft. above low-water level; this will give some idea of the size to which these bridges sometimes extend.

These structures are constructed of cane and bamboo, and their lightness and extreme simplicity are very remarkable. The cables are made from a species of rattan. They are from one to two inches in thickness and 20 or 30 yards long, knotted together, and the other pieces are fastened to them by strips of the same plant. The flooring is of bamboo, consisting of stems laid longitudinally, supported by cross pieces hung from the two upper cables, which also serve the additional purpose of keeping the latter apart. When properly constructed and strongly made, these bridges are easy to cross. A Lepcha, carrying 140 lbs. on his back crosses without hesitation, slowly but steadily, and with perfect confidence.

Hooker in his Himalayan Journals considers these Julungas, or cane bridges, characteristic objects of Himalayan art. He furnishes an illustration and description of them, and we are indebted to him for some of the particulars here furnished. But perhaps the best technical information in brief on this subject is that afforded by Major Sherwill. He says:

"The main chains supporting the bridge are composed of five rattan canes each; the sides are of split cane hanging from each main chain as loops, two feet apart, and two feet deep. Into these loops the platform is laid, composed of three bamboos, the size of a man's arm, laid side by side, the section of the bridge resembling the letter V, in the angle or base of which the traveler finds footing. Outriggers, to prevent the main chains being brought together with the weight of the passenger, are placed at every 10 or 12 ft. in the following manner: Under the platform and parallel to the stream strong bamboos are passed, and from their extremities to the main chain (of cane) split rattan ropes are firmly tied. This prevents the hanging loop or bridge from shutting up and choking the passenger. The piers of these bridges (for there are several of them) are generally two convenient trees, through whose branches the main chains are passed and pegged into the ground on the opposite side."

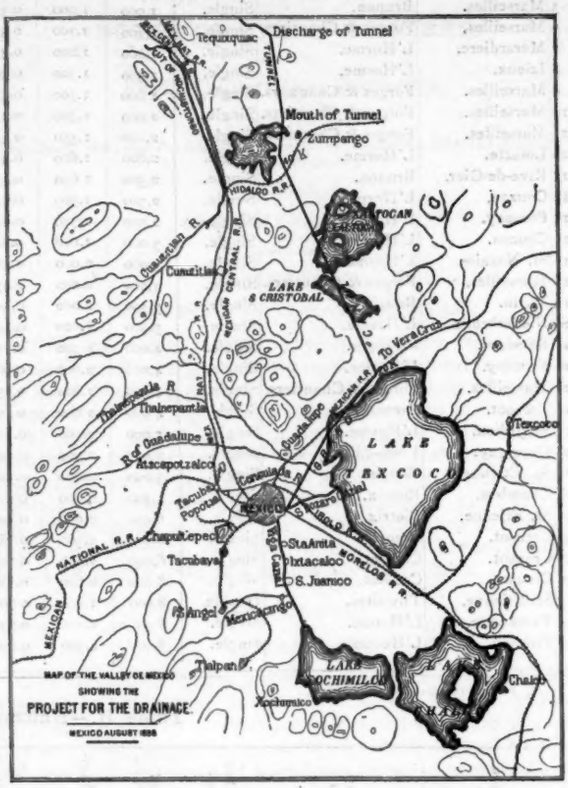
DRAINAGE OF THE VALLEY OF MEXICO.

THE project for the drainage of the valley of Mexico, which has been under consideration for a number of years, is now in a fair way to be at last carried out; a contract having been let to the firm of Read & Campbell, of London, for the tunnel and other works needed to complete it.

As is well known, the city of Mexico is situated in a valley, which, although it has an altitude of over 7,000 ft. above sea-level, is surrounded by still more lofty mountains and has no natural outlet. The area of the valley is about 1,650 square miles and a considerable part of it is occupied by six lakes, on the banks of one of which, Lake Texcoco, the city of Mexico is built. This lake is the lowest of all the six and would naturally receive their drainage, were it not for the artificial restraints which have been adopted to prevent their overflow, and resulting injury to the city.

The first attempt to drain the valley was made as long ago as 1604, and some 20 years later a tunnel was cut through the mountain wall by which a portion of the surplus waters was carried off, but 30 years afterward the constant trouble with this tunnel induced the Government of that time to convert it into an open cut. This work took nearly 150 years to complete, but it finally assumed its present form. The cut of Nochistongo, as it is called, is 13 miles long, about 360 ft. wide, and in some places over 200 ft. deep. It served its purpose as an outlet for some of the lakes during the rainy season when the surplus water in the valley exceeded that removed by evaporation.

In 1856 there was first suggested the plan for draining the lakes of the valley—and especially Lake Texcoco—by a tunnel, which would so reduce their level as to remove all danger of overflow water caused by an unusual rainfall, and would at the same time serve to carry off the sewage of the city, which is now discharged into Lake Texcoco, and which causes a great deal of trouble in high water. The plan adopted at that time was devised by Don Francisco Garay, but its execution was delayed by political troubles, and although some work was done in 1866, nothing was completed. Lately a new project was adopted by which the lake was to be controlled by securing so low a level that continued rains would not raise it sufficiently to flood the city, or to back up the sewage. Under this plan it is estimated that the volume of water to be disposed of during the five rainy months is 196,000,000 cubic meters, requiring an approximate discharge of 15 cubic meters per second.



The canal, which constitutes the principal feature of this plan, is divided into two parts. The first section, which is 12.4 miles in length, has to carry water from the lake to the city of Mexico only. The second section, which is to have nearly three times the capacity of the first, has to carry the surplus water of the lake and the discharge from the city; this section is 17.4 miles in length and 21 ft. deep. The flow of the lake water into the canal will be controlled by gates, and the fall for the whole length is 1:5,000. The most important part of the works, however, is the tunnel, which will commence at the end of the canal and extend through the mountains for a distance of 9,520 meters (5.9 miles), with a deep cutting about 500 meters (1,640 ft.) in length at the outer end. The fall through the tunnel is 1:1,000 and its cross-section will be semi-ovoid—that is, of the form which has been adopted for large sewers, as giving the lowest resistance and as best adapted for a variable flow of water. The upper, or arch part of this tunnel will be lined with brick and the lower part with stone and cement. Much of the work which was done over 20 years ago can be utilized in the construction of this canal. This includes the sinking of 24 shafts and the excavation of about 1,000 meters in length. The shafts are about 400 meters apart, and the deepest is about 100 meters in depth. The new contractors propose to work both ways from each of the 24 shafts, and in so doing

they will have to provide an extensive pumping plant to dispose of the water met with in excavation, in addition to the hoisting and other engines required for the work. Each shaft will have two engines, one for pumping, the other for hoisting and ventilation, which will be effected by means of Root blowers. The contractors will also establish extensive yards for making the bricks required for lining the tunnel and kilns for burning the lime, from lime-stone obtained in the neighborhood. There will also be an electric light plant for lighting the tunnel during the progress of the work.

This very important and interesting engineering work will be carried on entirely under English direction. Native labor will, of course, be employed, but under the management of English foremen and engineers. The general features of the valley and of the country through which the canal and tunnel pass are shown by the small map printed herewith.

A FRENCH ENGINEER ON AMERICAN BRIDGES.

(M. Le Rond in the *Annales des Ponts et Chaussées.*)

THE construction of metallic bridges has made great progress since the publication of the work of MM. Lavoinne and Pontzen, both in relation to the system of bridges and the method of execution and in the nature and quality of the material used. Works daring in their design and of a kind entirely new have enabled us to cross in an admirable and comparatively inexpensive way ravines and rivers, which had heretofore defied the engineer, and steel has almost entirely replaced iron in bridge construction.

For a description of the earlier American bridges the engineer may consult with advantage the works of Malezieux and of Lavoinne and Pontzen. We propose here to give a short summary of the actual state of the art of bridge construction in America.

We will pass by entirely wooden bridges, although the railroad lines still use, especially in the Far West, many wooden bridges, often of considerable span; thus, for instance, at Albany, over the Willamette River, there is a Howe truss draw of 260 ft. span.

Generally speaking American bridges may be divided into four principal types:

1. Girder or Truss bridges.
2. Suspension bridges.
3. Arch bridges.
4. Cantilever bridges.

Of these four classes of bridges we will speak separately.

I. GIRDER OR TRUSS BRIDGES.

These bridges are the true American type of bridge and include the greater part of the works yearly constructed in that country.

They consist of members composed of simple elements, divided into chords, posts, and ties, each member being usually exposed to only a single kind of strain, compression, or tension, to the exclusion of all bending moment, and held together by pins.

The trusses, in which the parts are called upon to resist only a single kind of strain, include also counter-ties, which are only called upon to support a strain in certain unsymmetrical conditions of the load.

Bridge trusses may be divided into three classes: Simple, Multiple, and Complex.

A Simple Truss may be divided into a system of triangles, each having one side common with the adjoining one; an example of this is the Pratt truss, figs. 1 and 6.

A Multiple Truss may be decomposed into several simple trusses, the chords of which coincide; an example being the Linville, fig. 2.

A Complex Truss is a simple truss in which the effective bearing of the panels is reduced by constructing on these panels as a base a secondary truss; an example will be found in the Pettit truss, fig. 3.

The simple trusses most generally in use are the Warren, or triangular truss, fig. 4, and the Pratt truss, fig. 1.

The multiple trusses most used are the Linville truss and the multiple Warren truss. Linville trusses have been made triple and even quadruple, but the double is now the only one in use. In the same way the double triangular is the only one in use in truss bridges. Generally the points of crossing of the two systems (fig. 5) are used as points of suspension for the bridge floor, which reduces by one-half the length of the panels. The quadruple triangular system has been used in the construction of several riveted bridges.

The complex truss most used is the Pettit system. The Union Bridge Company also uses several complex systems, derived from the simple triangular system.

Multiple trusses, and especially the Linville truss, have been for some time the only ones used for large spans. Among these we may mention here the span of 520 ft. on the Cincinnati Southern Bridge over the Ohio, built by the Keystone Bridge Company, under the direction of Mr. Bouscaren; the steel bridges at Plattsmouth and Bismarck, each having three 400 ft. spans, and the Blair Bridge, also over the Missouri; these three bridges were designed and built by Mr. Morison, one of the engineers who has built most during the last few years. There may be mentioned also the Randolph Bridge over the Missouri, having three spans of 400 ft. each in steel, built by Mr. Strobel under the direction of Mr. Don J. Whittemore.

Nevertheless many engineers are giving up the multiple systems in favor of the simple and complex trusses. Reason and experience alike have shown that it was incorrect in practice to consider multiple girders as formed of simple girders working separately without interfering with each other, and that the calculation of strains under this hypothesis is always subject to doubt. In simple or complex girders, on the other hand, the strains can be ascertained by calculation with great exactness. Moreover, a number of important works have been built in recent years on the Pettit system—the Cincinnati & Covington Bridge, over the Ohio—or even on the Warren system—the Henderson Bridge, over the Ohio, with a channel span of 522 ft.—or the Pratt system—the bridge over the Hawkesbury River, New South Wales, with seven spans of 408 and 416 ft. The application of a simple system to long spans is something entirely new in American construction, and it is marked by a tendency to substitute long panels for the short panels of the old systems.

Simplicity of construction and the advantage of having in a span only a single form and a single length for all similar parts, the cross-section alone varying, long since caused American engineers to give up the slight economy allowed by making the trusses of a variable height.

It may be said, however, that broken or jointed chords have entered into practice for some years past, and are now frequently employed in small Pratt trusses, in the form of an inverted bow-string (fig. 6), and in large spans of the Pratt and Pettit types. Instances are found in the Van Buren Bridge, the Sault Ste. Marie, the Cincinnati & Covington, and the Hawkesbury River bridges. There has even been built, at Pittsburgh, in 1883, a bridge of the bow-string type, recalling the bridge over the Rhine at Mayence, and Mr. Bouscaren has built, in 1886, a bow-string cantilever over the Licking River at Newport.

American truss bridges are always pin-jointed, although some companies, like the Union Bridge Company, have built riveted truss bridges; for instance, one of the quadruple-triangular system, of 187 ft. span, over the Hudson River at Troy. But we cannot from this conclude that the Americans are giving up the pin-joint for the riveted construction; in fact, the example which we have just cited remains a solitary one, and this work has been done only by a single company, which is remarkable in recent years for the efforts which it has made to improve construction, and by the attention which it has given to the building of large cantilever bridges. Aside from this exceptional example the span of riveted girders is generally limited to 100 ft. Below that limit the pin-jointed trusses are too light and offer too little resistance to accidents, such as derailments, and plain riveted girders are generally used, but all the bridges of medium and of large span are built on the pin-joint system.

Far from giving up this system, American engineers have entirely abandoned in their construction certain old

arrangements, such as the sleeve-joints formerly used by the Phœnix Bridge Company, or the riveted joints used in the Cincinnati Bridge or the Kentucky River viaduct, and specifications always require that all the joints should be pin-connected.

The principal objection which American engineers make to riveting is, that it cannot be well done in the shops. For this reason they limit as much as possible connections of this kind in their works, and take care generally to put upon rivets, driven in place, only a sort of passive work, requiring them to keep the assembled pieces in their respective positions only, and not to transmit any strain from one to the other.

The counter-bracing of American trusses is ordinarily pin-jointed also, and is composed of compression members, which are at once special parts and ordinary members of the structure, and are generally crossed and joined together by adjustable fastenings. The flexibility resulting from this arrangement, however, has some inconveniences, and in recent works an application of riveting more or less extensive has been made to the counter-bracing, as will be found in the Omaha, the Randolph, the Poughkeepsie, and other bridges.

The floor-system of American bridges is generally composed of beams or girders supported directly by the pins or bolts of the truss, and joined together by longitudinal girders which carry the road. The road, or track, is laid upon cross-ties, or in exceptional cases upon longitudinal sleepers. The floor in American bridges is only subjected to bending strains; it rests upon fixed points, being either carried upon the upper chord in deck bridges or suspended from the lower chord in through bridges.

In many new works the floor-system and the counter-bracing only are of iron, the rest of the bridge being of steel.

It may be said in a general way that in late years American engineers have sought less to create new types than to eliminate the imperfect or complicated types formerly used, and to perfect the parts and the methods of construction of their favorite types. The study of the progress realized in this direction is very interesting and instructive, but the limits of the present article do not permit us here to enter fully into the developments, which must be reserved for a more detailed study.

2. SUSPENSION BRIDGES.

America possesses the largest and, it may be said, the best suspension bridges. The works of this class have been built with very great care, and the systems employed have been such that they could be applied without danger to the longest spans and the heaviest rolling loads. We have not here space for any full description of these works, accounts of which may be found elsewhere. These bridges may be divided into two principal classes:

1. Suspension bridges with a rigid floor and inclined wires or ropes, which include the largest and the finest bridges, such as the Suspension Bridge at Niagara Falls, 823 ft. span, the Cincinnati Bridge, and the Brooklyn Bridge, 1,600 ft. span.

2. Suspension bridges with a rigid cable, of which there are two examples at Pittsburgh; one over the Allegheny, with parallel cables united by triangular bracing, and the other known as the Point Bridge, over the Monongahela River.

Suspension bridges are theoretically more economical than trusses, but the advantage, very light when we speak of American trusses, disappears in the execution, in consequence of the greater quantity of hand-work required in suspension bridges and the high cost of that kind of work in America. Thus, no important works of this kind have been undertaken since the Brooklyn Bridge, but a well-known engineer, Mr. Lindenthal, has recently proposed to build a suspension bridge carrying six tracks, which will cross the Hudson River with a single span of 2,850 ft., resting upon steel towers 600 ft. in height. This bridge, which would include also two shore spans of 1,390 ft. each, would have both rigid cables and a rigid floor system.

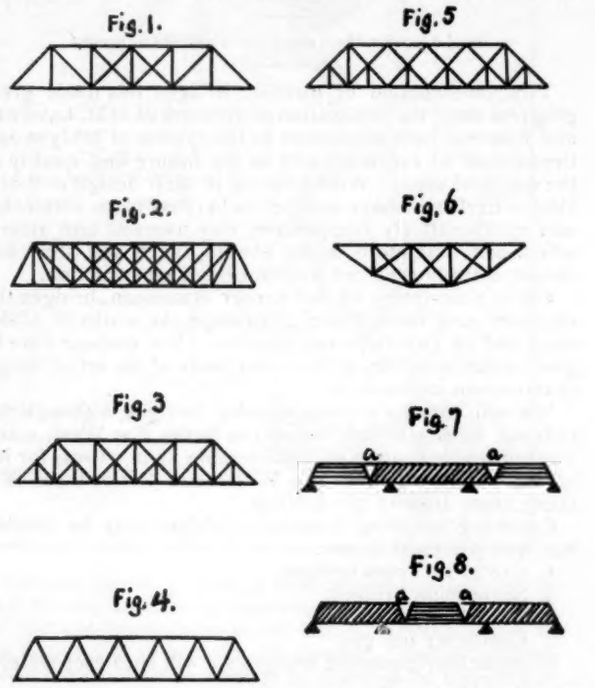
Nevertheless, since the invention of the cantilever system, in spite of the advantageous work of metal in suspension bridges, the era of those bridges seems to be at an end, and Mr. Lindenthal's project seems to be far from execution.

3. ARCH BRIDGES.

The fine arch bridge over the Mississippi at St. Louis, has remained for a long time without imitation in America. The reason is, that with these, as with suspension bridges, the expense of construction is considered too great.

This year, however, a very fine arch bridge, known as the Manhattan Bridge, and having two spans of 510 ft. each, has been built over the Harlem River, in the suburbs of New York. This bridge is built upon centers and has riveted counter-bracing. The arches are full, like those of Nantes, and carry the floor by means of columns, which are counter-braced only in a transverse direction.

This elegant system is not without its inconveniences in a work of the size of the St. Louis Bridge. This bridge carries a very heavy railroad traffic, and, in consequence, doubtless of the vibrations inevitable in this system, the rails of each track creep about 2 ft. a day, in the direction in which trains travel and no method has yet been found to stop this creeping. It may be noted, however, that the floor of the St. Louis Bridge has been recently entirely rebuilt, and at this writing the results have not been reported.



4. CANTILEVER BRIDGES.

The invention of cantilever bridges has been the greatest step in advance realized in America in the art of construction. These remarkable works have not generally the elegance of an arch bridge, but they have definitely solved the question of the construction of bridges of very large span. The building of the great suspension bridges and of the arch bridge at St. Louis, had proved that the economical solution of the problem did not lie in those systems. The complete solution, from both a practical and economical point of view, was for the first time furnished by the building of the Kentucky River Bridge, by Mr. Shaler Smith.

In this bridge the central span extends beyond the supporting points and carries the lateral spans, as shown in the small diagram, fig. 7. In the bridge built by Mr. Schneider at Niagara Falls, on the other hand, the lateral spans are extended beyond the points of support and carry the central span. This modification is shown in the small diagram, fig. 8.

In both types the free suspension of the central span is secured by a special arrangement, which can be reduced

strictly to a pin-joint on one of the chords and a sliding-joint on the other. The sliding-joint in both cases is shown at *a a*, figs. 7 and 8.

The first type is represented by the Kentucky River Bridge and by the Minnehaha Bridge, of Mr. Shaler Smith, and by a plan for a great cantilever bridge, which was prepared by Mr. Bouscaren, for the Cincinnati & Covington Bridge, but which was not carried out, having been replaced by a work with separate spans. The second type finds examples in the Niagara Bridge; the Frazer River Bridge, on the Canadian Pacific, also by Mr. Schneider; the St. John Bridge, by the Dominion Bridge Company; the Kentucky & Indiana Bridge at Louisville, and the Poughkeepsie Bridge, by the Union Bridge Company.

To this type also belongs the Lachine Bridge, having two cantilever spans of 400 ft., and a total length of 3,520 ft., built over the St. Lawrence River, for the Canadian Pacific Railroad, by the Dominion Bridge Company, from the designs of Mr. Shaler Smith. In this bridge, perhaps the finest of its class, which consists of two connected cantilever spans, the suspended span does not exist, and the two cantilever arms being joined, the bridge in reality, forms a continuous girder carried upon five supports. Alone among all the bridges of its class so far built, it has the two cantilevers joined in this manner, which requires a symmetrical construction and balancing upon the central pier.

Cantilever bridges have a double origin, first practical and then theoretical.[1] The idea of the cantilever construction dates back evidently to the St. Louis Bridge, but the construction of that work, without the ordinary false-work, required the construction of immense wooden towers, to carry the suspending cables used until the arch was completed, and the Kentucky River Bridge was the first built without any intermediate supports.

In a theoretical point of view cantilever bridges are continuous girders carried on four supports and jointed at two places in their span. They are, then: 1. So far as they are continuous girders, lighter than bridges of separate spans. 2. Lighter than ordinary continuous girders, from the fact that the bending moment is nothing at the points of suspension, for any distribution of weight which may be made, and that the position of these points can be chosen in such a way as to secure a maximum economy.

The complete theory of the cantilever system involves other considerations, which we hope hereafter to develop in a detailed study of the type, and for which there is not room in this paper. We must limit ourselves to the few following statements, which will be sufficient to establish the superiority of the American system in general and of the cantilever system in particular over the European systems, both from the point of view of rapidity and ease of construction and from that of economy.

Bridges with separate spans are erected on false-work; for the largest spans this operation takes at most one or two weeks. The Union Bridge Company erected, in *three days*, a span of 260 ft. in the bridge over the Arkansas, at Van Buren.

In the cantilever bridges the counter-weight span is erected on false-work, but the cantilever span without supports, the trusses sustaining themselves.

The Kentucky River Bridge, composed of three spans of 375 ft., was built over a ravine 280 ft. deep, without any false-work except a wooden pier to support the center of the bank-spans, the whole work taking 116 days. The metallic part of the Niagara Falls Bridge, which includes two lateral spans of 108 ft., and a central span of 495 ft. resting upon metallic towers nearly 200 ft. in height, was built between August 29 and November 22, 1883. The bank-spans were erected on false-work and the central spans without supports.

The Kentucky River Bridge, which is of iron and carries a single track, had in all in the structure 1,642 tons of metal, of which 1,283 tons were in the trusses and 359 tons in the iron towers. According to Mr. Lindenthal, three spans of the ordinary type would have weighed 1,579 tons for the superstructure alone, or 286 tons more than the actual weight of the bridge. The cantilever system in this work may thus be credited with a saving of about 18 per cent in metal over the ordinary American system. If, now, we compare it with the average weights of European bridges, taking as a standard the tables given by Inspector-General Croizette-Desnoyers, a riveted girder of the European type of the same span would weigh 5,270 kg. per running meter—that is, 668 kg. more than an ordinary American bridge and 1,570 more than a cantilever bridge.

The cantilever bridge at Niagara Falls, which has a double track and is in part of steel, required altogether 2,035 tons of metal, of which 1,670 tons are in the superstructure. The proportion of steel used is about one-quarter. Three separate spans of the American pattern and of the same length, with the same proportion of steel, would have required 2,009 tons for the superstructure, so that the economy of the cantilever system in this case was about 17 per cent. If we compare these weights with that of a European bridge of the same span, we find that such a bridge would have required 2,700 tons of metal, if all of iron, or 2,200 tons if one-quarter of steel.

From this example we find that the saving in material of the ordinary American bridge over the European system is about 10 per cent., while with the cantilever the saving would be about 24 per cent.

It is true that pin-jointed and especially cantilever bridges show greater deflection under the passage of a rolling load than riveted bridges, but this deflection would not present any serious inconveniences except for the passage of trains at a very high speed, and it is always easy to avoid them by a careful study of designs. They do not constitute by any means a vice inherent to the American system.

It is, perhaps, useless here to enter at any length into the old discussion of the relative merits of pin-jointed and riveted bridges. It is, perhaps, best to conclude with a distinguished American engineer, that the final decision will come to a point between that now claimed by the extreme advocates of both systems, and that the final solution will be a mixed one.

In fact, it is toward this mixed solution that American practice is now tending, by the adoption:

1. Of riveted girders for small spans, the limit at which it is best to cease applying this system being not yet definitely fixed, but perhaps generally taken at about 100 ft.
2. Of pin-jointed spans in all other cases.
3. Of riveted counter-bracing in pin-jointed bridges of large dimension.

CONCLUSION.

From this study, and from the examples which we have given and which could easily be multiplied, it follows that the American methods of construction have a certain number of incontestable advantages over the methods pursued in Europe.

1. In American bridges, even of the multiple system, the strains are much more exactly defined than in any riveted system, and in the bridges of the simple system the knowledge of the strains is absolutely certain.

2. The construction of these works is much more simple and more rapid than that of European bridges.

3. The cantilever system permits us to span large openings at any height whatever, and works built on this system are not exposed to accidents, such as happened at the Tardes Viaduct and which are always to be feared when it is necessary, as in that case, to launch a completed span upon the piers. Moreover, the use of the pin-joint construction permits the execution of these works with astonishing rapidity. The Forth Bridge, where the English have applied the cantilever system, and which, under construction for several years, is still far from completion, could have been built in much less time on the pin-joint system.

4. Finally, the different American systems realize a saving of from 10 to 30 per cent. over our bridges in weight, and the saving in hand-labor is still greater.

It remains for us to prove that these advantages are not counterbalanced by a want of rigidity, by an excess of strain imposed upon the metal beyond the limits allowed by us, nor by increased difficulty of cost of maintenance. To answer these criticisms it is necessary to study in detail:

1. The principles applied to the use of metal in Ameri-

can bridges. 2. The form given to the members according to their work and the method of assembling the parts. 3. The method of construction of the different members of the metallic trusses, the nature and quality of the metal employed, according to the parts in which it is used, the work to which they are submitted in the shops and the tests made of them both before and after they are put into their final form.

Such a study is necessary to justify the adoption of the pin-joint construction, since there is always a difference between theory and practice, and to undertake an important work on this system without profiting by the long experience of American engineers, would be to invite almost certainly some of the accidents which happened when this kind of construction was first adopted. To prove this we may give a single example. At the Bismarck Bridge, a very remarkable work, which we have already had occasion to mention, the order of two eye-bars meeting at the central pin was reversed by a mistake; although the reciprocal displacement of each of these bars amounted to hardly 3 cm., there resulted a strain of 21 kg. per square millimeter on the pin.

Pin-jointed bridges will not permit any carelessness or even mediocrity in the execution of the work, although it may pass in a riveted bridge.

HYDROGRAPHY AND HYDROGRAPHIC SURVEYS.

By Lieutenant Henry H. Barroll, U.S.N.

(*Continued from page 372.*)

V.—THE WINDS.

An important question to mariners is, of course, that of the winds; for while the increase of steam has to some extent rendered seamen less dependent on the winds than before, it is nevertheless true that a very large portion of the world's commerce is still carried in sailing vessels, and even steamers are largely dependent on the winds for favorable passages, so that a few observations on this question may not be out of place.

The general definition of wind is, "Air in motion." If the earth had no rotary motion about its axis, there would be winds only from the north in the northern hemisphere, and from the south in the southern hemisphere.

These would be caused by the airs at the equatorial regions becoming heated, and therefore rarefied, and rising; while the colder air from the polar regions would rush in to fill the space thus left.

The rotation of the earth on its axis, however, acts to change this direction, and the polar currents, approaching the equator from the north and the south poles, are deflected momentarily, and cause the winds to appear to be coming from N.E. and S.E.

These polar currents form what are called the "trade-winds." They are the great arteries in the air circulation of the world, as the great equatorial currents are to the water circulation or as the aorta is to the blood circulation in the human body.

It will be readily seen that with the wind in the northern hemisphere blowing from northeast, and in the southern hemisphere from the southeast, there will be a line or band between the two, where their forces will neutralize each other. This is near the equator, a belt of some 600 miles, and which is called the Region of Calms. In this equatorial belt, as well as in the trade-wind belts, there are frequent disturbances, but the trade-winds speedily recover their comparatively regular force and direction. The trade-winds are not felt at the earth's surface in higher latitudes than about 30°; and they "swing with the sun"—that is, they extend farther north or south, according as the sun is in its northern or southern declination.

These winds, comparatively steady and reliable in strength and direction, have been denominated "trade-winds," from the great assistance which they give to commerce. There are four regions of trade-winds—the Atlantic, Northeast and Southeast trades, and the Pacific, Northeast and Southeast trades; each divided by the equatorial calm belt before referred to.

The knowledge which we now possess of the trade-winds enables us, unerringly, to place upon each monthly issue of the North Atlantic Pilot Chart the line showing the "sailing route from Europe to America, by way of the trades," for that month, and the data returned each succeeding year, from vessels following these routes, adds to the exactness of future predictions.

The winds are divided into three general classes—steady, periodic and variable. The trades are the only winds that can be called steady; and even these, as has been before stated, are at times interrupted and changed in direction by local disturbances.

Periodic winds are those which, while blowing only at certain times during the year, yet during that time blow with a comparatively steady force and direction. To this class belong the monsoons of the Indian Ocean, which blow for about six months in one direction, and the remaining six months in an opposite direction. The harmattan, a warm, dry wind peculiar to the west coast of Africa, blows in series of three, six or nine days. To the class of periodic winds might also be added the general sea and land breezes at night and morning, caused by the radiation from the earth's heated surface.

Variable winds are those which do not, apparently, have any regular cause for their existence, and which do not, apparently, follow any regular course. I say "apparently," because in later years we begin to find that there is a natural cause for every gale that blows, and that in their course they follow laws with regard to force and direction as exact as those of the trade-winds.

The cold, straight current of air sweeping across the Texas plains from the north or northwest is denominated a "norther," while the similar wind, rushing from the south across the "pampas" of the Argentine Republic, is called a "pampero."

The more violent gales are called tornadoes, cyclones and hurricanes. A tornado (from the Spanish "Tornar," to return, to come back again) derives its name from the fact that the wind shifts its direction during the blowing of the gale.

A cyclone is a whirlwind, sometimes 400 or 500 miles in diameter, and with a comparatively calm center, which travels along a parabolic curve from the equator toward the pole—northward or southward, according to the hemisphere in which the gale occurs.

Circular storms are variously denominated cyclones, tornadoes, typhoons or hurricanes. These are but different names for storms of the same character. The typhoon (great wind) of China is identical with the cyclone of the North Atlantic or the ouragan of the Indian Ocean.

A cyclone is a gigantic whirlwind blowing around a comparatively calm center, this center also moving gradually along from the tropics toward the poles.

This center, instead of being a place of safety, is subject to violent and sudden squalls or gusts of wind and high, confused seas.

Its comparative calmness is caused by the enormous inward pressure of those immense air-walls, and is the result of their neutralizing forces.

The rate of speed of the storm center varies. Its motion is always very slow, as compared with the terrible velocity of the air-current whirling about it.

In storms passing along our coast, when the wind will be blowing at the rate of 60 to 100 miles an hour, *or* 1,500 *to* 2,500 *miles a day*, the storm center may move only at the rate of 100 to 120 miles in 24 hours.

The limits of this article will not admit of an extended discussion of the several theories as to the causes of cyclones. I will only say that these hurricanes, rushing from the tropics toward the poles, carry immense volumes of air from the great trade-wind belts, and that this serves to restore equilibrium when local disturbances in the higher latitudes have caused a want of equilibrium.

Until the nature of these storms was understood their effects were terrible, but with a better understanding which we now have, vessels can to a great extent avoid them, or at any rate escape their worst effects.

VI.—OCEAN CURRENTS.

Currents form another question of very great importance to navigators. An ocean current may be defined as a river or stream of water moving on the surface of the sea. There are also other currents underneath the surface, and called submarine currents, but these do not directly affect the motion of vessels. Ocean currents are caused by winds and other influences, but not by tidal influence, which is felt only near the coast.

The limits, direction, and velocity of the several ocean currents have been largely determined by the drift of bottles, which have been thrown overboard for that purpose from vessels, and having securely sealed in them the date and position of the vessel at the time the bottle was put overboard. These being afterward recovered, show by the date and locality in which they were picked up, the strength and direction of the current which has borne them there. Among the blank forms furnished to those merchant vessels which record observations for the Hydrographic Office, is one to be filled out, and placed in the bottles thus thrown overboard. This paper contains the following sentences, printed in English, French, German, Italian, Portuguese and Spanish :

" Ocean Current Report."

" Thrown overboard by (give name of vessel, date and position)."

" Found by (give name of vessel, date and position)."

" Please send this to any United States Consul, or forward it direct to Washington."

These little wanderers go floating about the seas, and the information that they contain is carefully preserved.

Of all the currents of the ocean, probably the best known is the Gulf Stream, in the Atlantic ; this has been the most closely observed, because the commerce of that part of the ocean through which it passes is greater, and the number of vessels whose course is affected by it, is larger than is the case of any other current in the world. The Gulf Stream has its counterpart in the Pacific, in the Kuro Siwo, or great Japanese current, which flows across the Pacific, and which moderates the climate of the Northern American shore of that ocean in the same way that the Gulf Stream does that of Western Europe. Both currents are formed in the first place by the breaking off of the equatorial current striking the American shore of the Atlantic and the Asiatic shore of the Pacific. The knowledge of the force, direction and speed of these currents is of great importance to vessels, much time being often saved by the intelligent use of their assistance.

VII.—TIDES.

The question of tides has engaged much attention from the hydrographer. As is generally known, of course, the tides are the result of the attractive forces of the sun and the moon, the moon having by far the greater influence, owing to its comparative proximity to the earth. In discussing this question care must be taken that the *tidal currents*, or horizontal motion of the waters, be not confounded with the upraising of the sea. There are two entirely distinct phenomena caused by this tidal action. One of these is a perpendicular motion, a *rise* and *fall* of the waters, alternating with more or less regularity. The other is a horizontal motion, or *current*, flowing to and fro, also with more or less regularity. These phenomena are frequently confounded, being collectively spoken of, as " the tide." It has become customary, however, in modern times, to refer to the stream as the " *tidal current*" or " *tidal drift* ;" and to use the word " tide," only when strictly referring to the *change in elevation* or the *rise* and *fall* of the waters.

As both the sun and the moon have an influence upon the tides, this influence is of course greatest when both act in the same line. Therefore, the *highest* high tides and the *lowest* low tides are those occurring at full and at new moon, and are called spring tides.

When the moon is in its first or its third quarter, its attracting force, instead of acting with that of the sun, is acting at right angles to that force ; and the *high* tide caused by the moon will occur at the time of the *low* tide caused by the sun, and *vice versa*. Thus, the *lowest* high tides and the *highest* low tides of the lunar month will occur when the moon is in its first or in its third quarter.

These smallest tides are called neap tides.

It may be noted, however, that the highest tides do not occur at exactly new or full moon, but always a day or two later.

The rate at which the tidal elevation of water is carried westward is very rapid. The motion of the tide-wave can be thus described : Suppose a rope to be held by two persons, at some distance from each other. Now should one of them give this rope a sudden shake, up and down, the wave of this force will be carried along to the other person's hand rapidly ; more rapidly than one person could run to the other, carrying the rope.

It is a *translation of motion ;* while the *tidal current* or *drift* that affects vessels, and which some people call " the tide," is an absolute *transfer of waters* from one place to another.

If the earth's surface were completely covered with water, and we should neglect the slight retardation due to friction, then the tide wave would follow the moon in its course, traveling at the rate of 900 miles an hour, from east to west.

Owing, however, to the retarding influences of shoals, islands and the coasts of the continents themselves, the velocity of the tide-wave is much diminished. It, however, travels at a much greater speed than any tidal current. The tide easily travels at the rate of 60 miles in 60 minutes, while tidal currents rarely exceed two or three miles per hour. The tide-wave comes from Gibraltar to Cape Henry, a distance of about 3,800 miles, in about 14 hours, or at a rate of about 270 miles an hour. In rivers and bays, however, this speed is retarded, not only by the shoals and points with which the flowing waters come in contact, but also the incoming tide is retarded by the currents of the rivers flowing into the sea. So swift is the current of some rivers, that there is no surface tidal current visible, the rise and fall and a slackening of the river's current being the only indication of the change that is taking place.

In the Chesapeake Bay the tidal wave travels at the rate of about 15 miles an hour.

(TO BE CONTINUED.)

A SIBERIAN CANAL.

(M. de Mas in the *Annales des Ponts et Chaussées.*)

ABOUT 200 miles above Tomsk the Obi receives on its right bank a large tributary, the Kete River ; about 162 miles above Yeniseisk the Yenisei receives, on its left hand, a stream of less size, the Great Kass. The upper tributaries of the Kete and of the Kass come almost in contact with each other in a marshy region without any considerable elevation, so that the basins of these two great Siberian rivers can be united under conditions more favorable than are often found.

The Kete is a large river naturally navigable ; it has been followed up from its junction with the Obi, for a distance which has not been exactly measured, but which is not far from 500 miles, the head of navigation being at the mouth of the Overnaia. It is between this point and the junction of the Great Kass with the Yenisei that we find the works for providing a water-way between the two rivers.

Fig. 1, herewith, is a sketch map showing the general course of the tributaries of the two streams and of the canal which is to unite them. The works are of the nature expressed in the table below :

		MILES.
A B.	Overnaia River, Navigable	9.95
B C.	Lomovataia River, Canalized	30.50
C D.	Jassevaia River, "	21.19
D E.	Grand Lake, Navigable	3.39
E F.	Canal	4.66
F G.	Little Kass River, Canalized	31.82
G H.	Little Kass River, Regulated	22.87
H I.	Great Kass River, Navigable	127.64
	Total	252.03

From this it will be seen that all the actual canal construction needed to put the two great rivers in connection is a distance of 4.66 miles, and in this distance the excavation required is nowhere over 18 ft. in depth.

The summit level, which includes a portion of the canal, Grand Lake, and a short section of river, is now completed. The position of the terminal locks, on this level, are shown on the sketch map at *P* and *P'*. Its total length of 12.12 miles includes 5.26 miles of the Jassevaia River, the 3.39 miles across the Grand Lake, and 3.47 miles of the canal.

The cross section of the canal is shown in fig. 2, and it is remarkable for the very gradual slope of the banks of the prism. This slope was adopted on account of the sandy nature of the soil, and the result is that the banks, although not protected in any way, are perfectly preserved. The terminal locks are 155 ft. in length and 28 ft. in width, with 5.6 ft. depth of water over the sills. These dimensions allow the passage of two small boats of the type used in that country at the same time. In fig. 2 the level of high water, in the spring floods, is shown by the line *a a*; the low-water level by the line *b b*.

The work of canalizing the rivers is progressing actively in both directions, and it will probably be completed—at least as far as the construction of the locks—by the end of next summer. On the side of the Obi and Kete the Jassevaia, in a total length of 46.36 miles, has a fall of 58.7 ft., which is overcome by six locks; on the side of the Yenisei the Little Kass, in a distance of 31.8 miles, has a

Fig. 1.

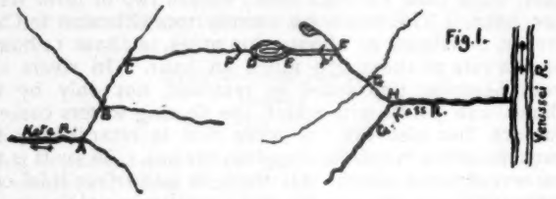
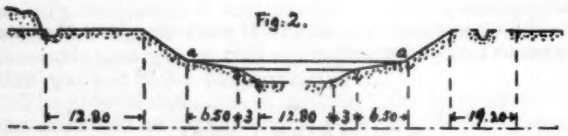


Fig. 2.



total fall of 51.6 ft., which is overcome by three single locks and one double lock.

The total estimated cost of all these works was only $950,000, but it is probable that this estimate will be considerably exceeded.

The only materials furnished by the adjoining country are wood and sand; stone is entirely unknown, and the iron, which is brought from the Ural mines, is very costly. The locks and the dams are, therefore, entirely of wood. The type adopted for the dams is worthy of attention; it consists of a fixed wooden bridge placed above the level of the highest floods, upon which rest heavy parallel timbers, the other extremities of which are embedded in the bottom of the river; the intervals between these timbers are closed by planks so arranged that they can be lifted when necessary to afford passage through for the water.

The difficulties resulting from lack of material, however, were the least of those encountered. The works are in a country absolutely uninhabited. Before beginning them it was necessary to build a village to bring the workmen there and to collect the supplies of every kind which were necessary to meet their material, moral and sanitary needs. Moreover, the rigor of the climate, where it is not uncommon to see the thermometer fall to 55° or 60° below zero, reduced the time of active work to a few months in each year. At Tomsk the average period of navigation is from May 10 to October 15. If we take into account the time necessary to transport the workmen to their place and to return them home again, it will be seen that the working season does not last over four months. During these four months from 1,200 to 1,600 men have been employed, while during the winter about 100 remained upon the ground and are employed in felling trees in the forest. About March 1 it becomes possible for carpenters to work in the open air, and a small re-enforcement is sent, but the great body of the workmen and of the necessary supplies, cannot be brought up until the Obi and the Kete are free from ice, so that boats can pass up them.

The labor, however, required will be well rewarded by the results, which will be obtained when the work is completed. The Ural Railroad, which is now completed from Perm in European Russia across the Ural Mountains to Ekaterinburg, is being extended to Tiumen in Siberia. That city is situated at the head of navigation of the Tiura River. That river falls into the Tobol, the Tobol into the Irtisch, and the Irtisch into the Obi. On the other hand, the Yenisei receives a little below Yeniseisk, the Angara, which is the outlet of Lake Baikal; lastly, this lake has for a tributary the Selenga River, which has its source among the mountains of the great Mongolian plateau, and which crosses the Chinese frontier near Kiakhta, which is the center of the overland commerce between Siberia and China.

When the Obi and the Yenisei are united there will exist a navigable route from Kiakhta to Tiumen, a distance of nearly 3,400 miles, substituting for that distance a cheap transportation for one which is now excessively costly. The importance of this will be seen when it is said that of tea alone some 18,000 tons passed through Kiakhta last year, and that the opening of the water line will reduce the cost of transportation to about one-sixth of its present amount.

It is to be considered, moreover, that this water line will make easy of access for the first time the vast valley of the Lena, now almost inaccessible. The head waters of the Ilim, the principal tributary of the Angara, approach within less than 60 miles the navigable waters of the Kout, a tributary of the Lena. The transportation of merchandise over this distance will be comparatively easy, and as the traffic increases there can be little doubt that a new canal will be constructed there.

It may be noted that the navigation of the Angara, near Lake Baikal, is at present obstructed by rapids, but M. Sibiriakoff, a distinguished engineer, who has made a careful examination of this region, has prepared a plan for a system of towing by which boats can pass these rapids with very little difficulty.

This work of connecting the Obi and the Yenisei has been under charge of Baron Aminoff as Chief Engineer; he has his headquarters at Tomsk, but passes the working season upon the ground, where he can exercise direct supervision of the construction.

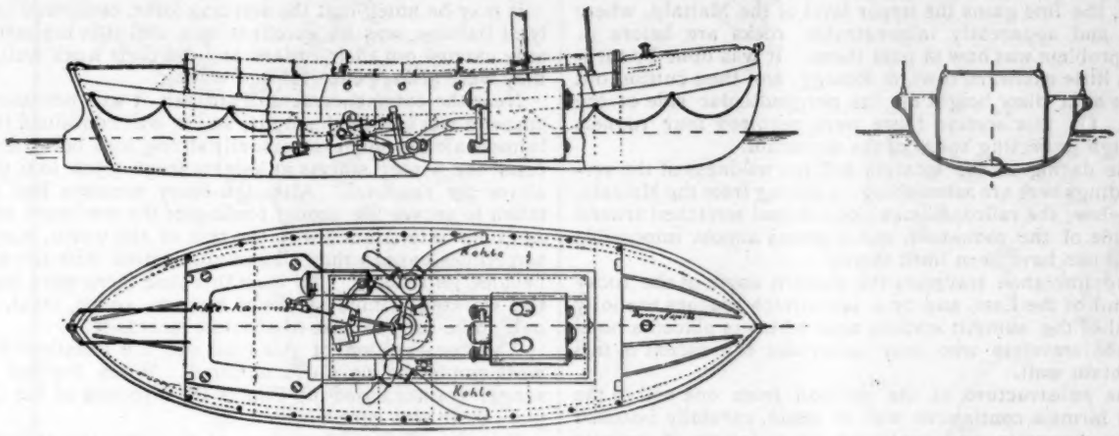
A NEW STEAM LIFE-BOAT.

THE accompanying illustrations, taken from the *Mittheilungen aus dem Gebiete des Seewesens*, show a life-boat with machinery for hydraulic propulsion, which is now under construction, and which is expected to receive the gold medal offered in England for a life-boat propelled by machinery. The boat and machinery are being built at the yards of R. & H. Green, in Blackwall, England. The illustrations show an elevation of the boat with part of the side broken away to show the position of the machinery; a plan and a cross-section.

The driving apparatus consists, as shown in the cut, of a powerful centrifugal pump, which takes in the water through pipes extending through the bottom of the boat, and expels it through other pipes passing through the sides. These are so arranged that the water can be forced out forward or backward and either to port or to starboard separately, so that the boat cannot only be propelled backward or forward, but can also be very quickly handled, turning in a very short space. The boat under construction is 50 ft. long; 12 ft. wide on the water line; 14 ft. 4 in. in breadth across the thwarts, and has a total depth of 5 ft. 6 in. With the crew, 30 passengers, and three tons of coal on board, it will draw only 3 ft. The engine is a compound engine, designed with especial reference to economy of space, and will work up to 170 H.P.; it is expected to drive the boat at the rate of 9 to 10 knots an hour.

There are 17 air-compartments placed along the sides, in order to give the boat the required buoyancy, and these are so arranged that two leaks will not impair seriously its floating power.

The arrangement of the weight is so carefully made that the boat can right itself from an angle of almost 90°, which, of course, increases very much its safety. The pump which serves to drive the boat is also so arranged that by a connection very quickly and easily made it can be used to pump water out in case any should be shipped or a serious leak sprung. The boat is provided with a mast carrying a spritsail and a jib, so that it can be sailed by wind power, and in that case the smoke-stacks can be laid flat upon the deck, in order to avoid interference with the sail. The mast is hinged at the foot, so that when not in use it can in its turn be laid down between the smoke-stacks, so as to be entirely out of the way when the boat is worked by steam.



STEAM LIFE-BOAT.

The hull is built of steel and strongly braced, and the total weight of the boat when completed and ready for service will not exceed 20 tons.

The boiler is calculated to carry a very high pressure. In the design of the boat the greatest pains have been taken to secure strength, safety, and lightness, and the speed has not been obtained at the cost of these qualities. It must be mentioned that the boat is provided with a small steam capstan at the bow, which is expected to do good service under many circumstances, and will also have the Hickman steering apparatus.

THE MOUNT PILATUS RAILROAD.

(From the *Revue Scientifique.*)

THE Mount Pilatus Railroad is the latest of the Alpine railroads, and also the most difficult of construction. Every one who has visited this line, which will be entirely open to the public in the present summer, joins in stating that the work is remarkable and that it will be a very great convenience to tourists. All strangers who visit Lucerne, the central point of voyages in Switzerland, have seen Mount Pilatus, whose lofty outline, with its sharp peaks and precipices, breaks so abruptly on the beautiful country surrounding that city. From the most remote times this strange mountain has impressed the imagination of the people of the country. From its slopes seem to come the most terrible storms. At sunset, when the other mountains are touched with the most beautiful colors, Pilatus alone always appears dark and gloomy, throwing its black shadow over the lake of the Four Cantons. Sometimes its head is hidden in the clouds, and again it towers proudly over the masses of vapor which hide its base. It has always a physiognomy different from the other mountains, and innumerable traditions have been circulated about it in the Alpine country. It was believed for a long time to be inhabited by winged dragons, phantom birds, gnomes, and petrified saints. Pontius Pilate, whose name it bears, was said to live in the little lake on the mountain, and if, by chance, any one should throw stones into that lake, he would issue forth and scatter devastation and death over the country. In the Middle Ages the people were so convinced of this fatal power of Pilate, that the City of Lucerne forbade the ascent of the mountain under heavy penalties, and the city officers took a solemn oath to prevent any one from climbing it. It is only in comparatively recent times that the veil which covered this terrible mountain has been withdrawn. Ever since the great Genevese naturalist, Saussure, made known the sublimity and beauty of the mountain world, and Albert de Haller wrote his magnificent work on the Alps, thousands of visitors have climbed the mountain, and have not been able to praise sufficiently the grandeur of the view and the sublimity of its rocks and precipices.

Early in the present century the number of visitors became so great that it was necessary to establish a resting-place for them on the mountain. About 30 years ago, houses were built on the Klimsenhorn and in the valley or depression which separates the Oberhaupt and the Esel, the two enormous masses of rock which form the summit of the mountain; but for many years the ascent was hardly possible on account of the difficulties involved. The idea was conceived of making the mountain more accessible, as had already been done with its rival on the other side of the lake, the famous Righi. Two energetic citizens of Zurich, Colonel Locher and M. Guyer-Freuler, published in December, 1885, a daring but carefully worked out project for a railroad up the sides of Pilatus. They found the necessary funds, and soon a company was organized. The names of the projectors were both well known, as they had, one as engineer and the other as contractor, already completed with notable success one of the most difficult sections of the St. Gothard line, from Flüelen to Goeschenen. To these two persons is mainly due the construction of the road, although there should, perhaps, be added a third, Major Britschgi, who rendered great service in securing the right to build a road through the commune of Alpnach, in which most of the line is situated.

Work was begun in the summer of 1886, and at the end of that of 1888, after two years—not more than half of which could be utilized on account of the severity of the weather on the mountain—the road is now substantially finished. From the village of Alpnach, which is situated at the extremity of the southwest arm of the Lake of the Four Cantons, the railroad rises by a very steep grade from a height of 1,446 ft. to one of 6,790 ft. above the sea-level, following the narrow ravine or pass between the rocky masses of the Oberhaupt and the Esel. The difference in altitude between the two extremities of the road is thus 5,344 ft. for the total length of 2.879 miles. The average grade is 42 per cent.—that is, an inclination of 22° 42′—and the maximum grade is 48 per cent., or 25° 39′. Higher grades have been overcome by cable roads, but this road

on Mount Pilatus is the only one on which grades of 48 per cent. are mounted by means of a rack-railroad system.

From the bottom of the valley the line rises across the meadows of Obsee, then enters a wooded valley and traverses the pine forest in the direction of the tremendous precipice which is known as the Wolffort. It crosses the chasm on a stone bridge, which is remarkable for its bold arch, and then passes through two tunnels to Risleten. There during centuries avalanches and landslides have formed on the side of the mountain an embankment of bowlders and rocks. Passing this, at Emsigenalp, the line reaches the region of pasturage, and at this point, which is marked by a group of gigantic pines, the station or passing place for trains is situated. The view is here already imposing. Always preserving a grade of 48 per cent., the line gains the upper level of the Mattalp, where huge and apparently impenetrable rocks are before it. The problem was how to pass these. It was done by turning a little eastward toward Rosegg, and then cutting out a line at a dizzy height on the perpendicular side of the Esel. On this section there were required four tunnels through projecting spurs of the mountain.

The daring of the location and the wildness of the surroundings here are astonishing. Looking from the Mattalp, far below, the railroad looks like a thread stretched around the side of the mountain, and it seems almost impossible that it can have been built there.

The line then traverses the western angle of the rocky summit of the Esel, and by a last stretch reaches the lofty portal of the summit station, near which is placed a hotel for the travelers who may undertake the ascent of this mountain wall.

The substructure of the railroad from one end to the other forms a continuous wall of stone, carefully fastened to the mountain and protected by a facing of granite brought from the quarries of Osogna in the valley of the Tessino.

The track is joined to the masonry by heavy iron clamps. It is composed of two ordinary rails and of the central rack-rail, which is on the Abt system, with a double row of teeth. The racks are made of steel cut out by a machine made especially for the purpose. The train consists of a locomotive having a boiler built to carry a pressure of 180 lbs., and of a carriage with four compartments arranged in staircase fashion. Its carrying capacity is 32 persons, besides the trainmen. Each carriage has two pairs of toothed wheels carried on a vertical axle, which engage on each side with the teeth of the rack. The care taken in the construction of the track, of the engines, and of the automatic brakes, which are constantly in action, excludes the idea of danger. The speed, both in ascending and descending, is about 2¼ miles an hour, and each train makes the trip up in about 80 minutes.

Rarely has a railroad been built under such exceptional circumstances as was this. The steepness of the slopes, which in the upper part are almost inaccessible, rendered the work very difficult. The engineers of the company and the workmen had as many dangers to run as the chamois-hunters and needed as much boldness and courage as they have, but under the direction of Colonel Locher and Chief Engineer Hauszler they accomplished their task with a truly heroic courage.

The difficulties of construction on the upper part of the mountain were very great. To reach the line of the road-bed it was necessary for the men to be lowered by ropes from above to their work, and drilling and blasting the rock, in places where it was impossible to find a foothold, were thus very difficult. In spite of the experience gained in the valley at the beginning of the work, the engineers and workmen found themselves constantly meeting new difficulties, and the director who had charge of each section had more than once to devise new means of meeting these obstacles.

The climatic conditions of the mountain opposed an equal obstacle to the organization and accomplishment of the work. Often the arrangements made in the morning had to be changed at noon on account of changes in the weather. This perpetual struggle against a thousand difficulties demanded far more patience and intelligence than has ever been required for the building of a railroad. Moreover, the line could not be begun at several points at once, as is the case with most railroads. The work could be carried on only at a single point, and it was not possible to make temporary roads to carry the material. A short section of the track was first built, and was then utilized to carry the material for the next section. In spite of this, however, it was necessary to employ mules as well as the united force of the workmen to move the material. The stone, cement, rails, etc., were carried by wagon to the foot of the work. Mules alone were able to resist the climate and the bad roads, and it would not have been possible to replace them by horses. As to the large stones from Tessino, they were placed on carts constructed for the purpose and drawn by 30 or 40 workmen to the place where they were to be used.

It may be noted that the working force, composed largely of Italians, was an excellent one, and that the men not only carried out their orders and did their work well, but they were always cheerful and willing.

Near the commencement of autumn it was necessary to suspend work in the open air, and it was continued in the tunnels alone, only exceptionally strong men being able to resist the winter storms at heights from 5,500 to 6,500 ft. above the sea-level. Although every measure had been taken to secure the proper feeding of the workmen and to keep up intercourse with the rest of the world, it would sometimes happen that all communication with the valley became impossible. To meet this case there were kept in the working camps stocks of biscuits, coffee, meat, etc., only to be used in case of absolute necessity.

The construction of this road and the grandeur of the work cannot be too much admired. When the first passenger train carried up Pilatus the directors of the Company there was general rejoicing.

In spite of the completion of the line, the summit of Pilatus is still covered with workmen actively employed in blasting out a level site for a new hotel, which will be placed near the summit of the Oberhaupt facing to the east and south, and protected against the storms which come from the north and northwest. Work has also been begun on a cable road, about 200 meters in length, which will carry visitors up an almost perpendicular ascent to the top of the Tornlishorn, the highest point of Mount Pilatus.

This might well be called the most remarkable railroad in Europe, and from the summit there can be attained a view without a parallel in the world.

JAPANESE RAILROADS.

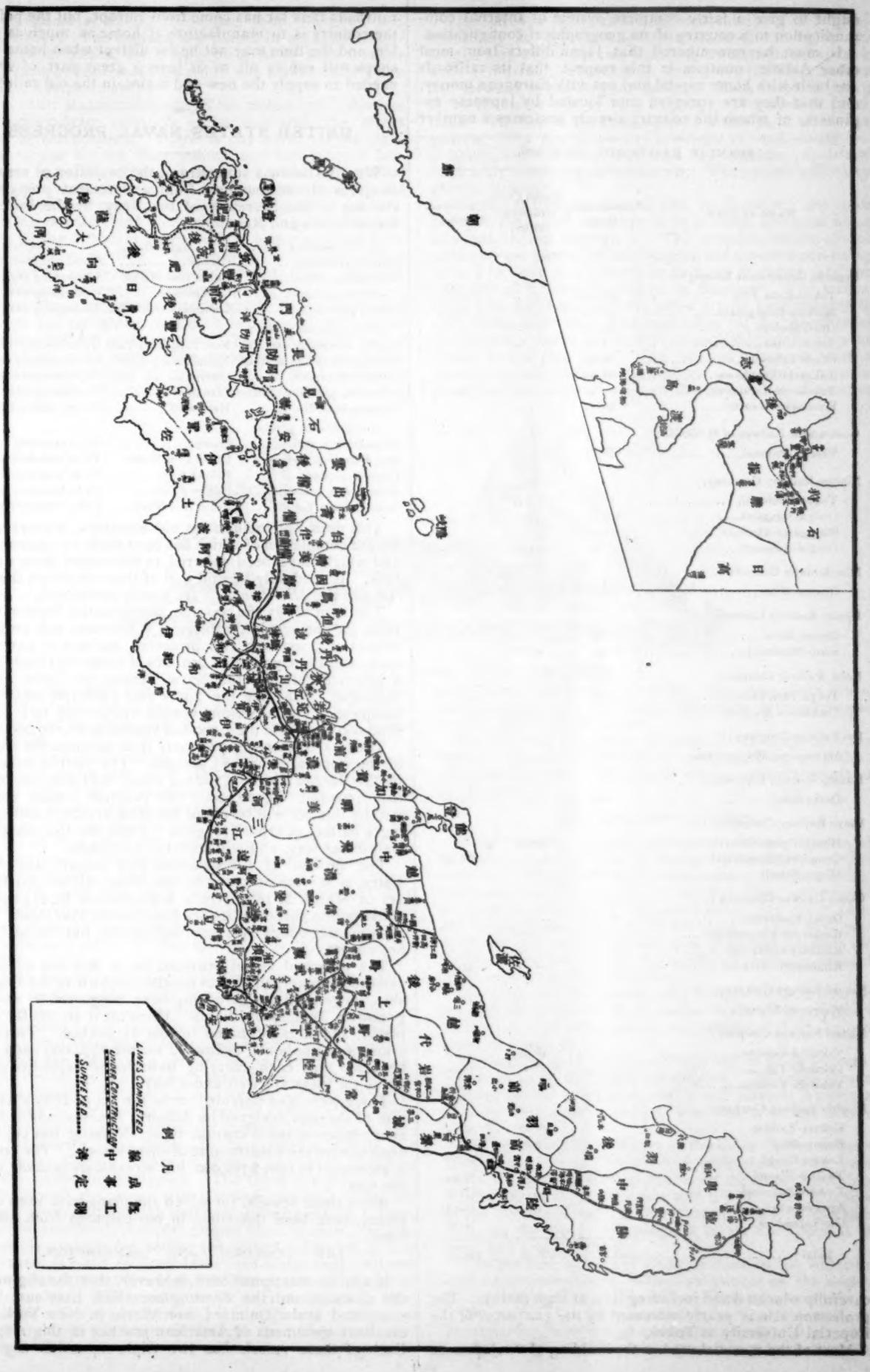
WE give below a table, compiled from the best sources, of the length of the railroads in Japan at the beginning of July, 1889, the separate columns showing the number of miles completed and in operation; under construction, and surveyed and located. A large part of the completed mileage is owned by the Government, but the lines owned by private companies also reach a considerable figure, and the greater part of the lines under construction are enterprises undertaken by corporations.

We give also on the opposite page a copy of an official map showing the location of these lines. The names are printed in Chinese characters, which, probably, few of our subscribers can read, but the general outline of the railroad system, completed and under construction, is well indicated, and the map will serve to show the careful work which is done by the Japanese engineers, and is a specimen also of the map-work done in that country—not of the finished maps, but the sketch and outline work.

Under the conditions obtaining in Japan, a line that is surveyed or under construction is pretty sure to be built, so that it may be safely said that in a year or so that country will have close upon 2,000 miles of railroad. The total now in operation, as given above, is 1,042 miles: under construction and surveyed, 923 miles; an aggregate of 1,965 miles.

In addition to these lines there are ten others projected, for which concessions have not yet been granted by the Government; the total length of these is about 600 miles.

With these, and others which will follow, Japan may look forward to a railroad system of some 3,000 miles in a few years; and this length of railroad, judiciously placed,



RAILROAD MAP OF JAPAN.

ought to give a fairly complete system of internal communication to a country of its geographical configuration.

It must be remembered that Japan differs from most other Asiatic countries in this respect, that its railroads are built with home capital and not with European money, and that they are surveyed and located by Japanese engineers, of whom the country already possesses a number carefully educated and including men of high ability. The profession also is yearly increased by the graduates of the Imperial University at Tokio.

Most of the material used in the building of the Japanese railroads thus far has come from Europe, but the policy of the country is to manufacture at home as much as possible, and the time may not be far distant when home workshops will supply all, or at least a great part of what is needed to supply the new and maintain the old railroads.

JAPANESE RAILROADS, JULY, 1889.

Name of Line.	Completed, Miles.	Under Construction, Miles.	Surveyed, Miles.
Imperial Government Railways:			
Tokyo-Kobe Line	376.39	.....	.....
Maibara-Kanagasaki	31.03	.....	.....
Ofu-Taketoyo	12.69	.....	.....
Bamba-Otsu	1.29	.....	.....
Ofune-Yokosuka	10.00	.....	....
Takasaki-Yokokawa	18.00	.....	.....
Yokokawa-Karuizawa	.....	.....	15.00
Karuizawa-Maoetsu	92.13	.....	.....
Government Railway of Hokkaido:			
Temiya-Poronai	56.65	.....	.....
Niphon Railway Company:			
Tokyo-Maebashi	68.15	.....	.....
Omiya-Shiogama	207.81	.....	.....
Shinagawa-Akabane	12.95	.....	.....
Iwagiri-Awomori	.....	240.00	....
Mito Railway Company:			
Oyama-Mito	41.56	.....	.....
Ryomo Railway Company:			
Oyama-Kirui	32.92	.....	.....
Kirui-Maebashi	.....	19.80	.....
Kobu Railway Company:			
Tokyo-Tachikawa	16.92	.....	.....
Tachikawa-Hachioji	.....	4.08	.....
Iyo Railway Company:			
Matsuyama-Mitsugahama	4.23	.....	.....
Hankai Railway Company:			
Osaka-Sakai	6.06	.....	.....
Sanyo Railway Company:			
Himeji-Onomichi	.....	101.00	.....
Onomichi-Shimonoseki	.....	.....	167.50
Hiogo-Himeji	33.08	.....	.....
Osaka Railway Company:			
Osaka-Kashiwara	10.13	.....	.....
Kashiwara-Kitaimaichi	.....	4.88	.....
Kitaimaichi-Sakurai	.....	.....	10 13
Kitaimaichi-Nara	.....	.....	11.88
Sanuki Railway Company:			
Marugami-Kompira	10.19	.....	.....
Kansei Railway Company:			
Yokaichi-Kusatsu	.....	48.95	.....
Yokaichi-Tsu	.....	.....	19.06
Yokaichi-Kuwana	.....	.....	7.91
Kiushiu Railway Company:			
Kokura-Tashiro	.....	56.93	.....
Kokura-Moji	.....	6.60	.....
Kokura-Gyogi	.....	..	13.08
Tashiro-Misumi	.....	.....	79.99
Tashiro-Nagasaki	.....	.....	87.69
Arita-Sasebo	.....	.....	13.94
Uto-Yatsushiro	.....	.....	14.38
Total	1,042.18	482.24	440.56

UNITED STATES NAVAL PROGRESS.

We give below a summary of the condition of vessels in progress of construction, from a statement prepared for the use of the Secretary of the Navy, by the Bureau of Construction and Repair.

	Builders.	Condition.
Act of March 3, 1885:		
Newark, cruiser	Cramps	To be launched in Oct.
Charleston, cruiser	Union Iron Works	Undergoing trial.
Yorktown, gunboat	Cramps	Undergoing trial.
Petrel, gunboat	Columbian Iron W'rks.	Undergoing trial.
Act of August 3, 1886:		
Maine, armored cruiser	New York Navy Yard.	Under construction.
Texas, armored battle-ship	Norfolk Navy Yard	Under construction.
Baltimore, cruiser	Cramps	To be launched in Nov.
Vesuvius, dynamite cruiser	Cramps	Undergoing trial.
Torpedo-boat, No. 1	Herreshoff	Under construction.
Act of March 3, 1887:		
Philadelphia, cruiser	Cramps	To be launched in Oct.
San Francisco, cruiser	Union Iron Works	To be launched in Oct.
Concord, gunboat	Palmer & Co	To be launched in Sept.
Bennington, gunboat	Palmer & Co	To be launched in Sept.
Coast Defense Vessel	Union Iron Works	To be completed in 3 yrs.

This does not include the old monitors, appropriations for the completion of which has been made by various acts, and which have been referred to heretofore from time to time. It need only be said that of these monitors the *Terror* and the *Miantonomoh* are nearly completed.

The sum of $3,760,000 was appropriated September 7, 1888, for one armored cruiser of 7,500 tons, one protected cruiser of 5,300 tons, two protected cruisers of 3,000 tons each, and three protected cruisers of 2,000 tons each; also a practice ship for the Naval School, the latter to cost $260,000. Plans for the 2,000 and 3,000-ton vessels are complete. The 2,000-ton vessels are limited to a cost of $700,000 each, and the 3,000-ton vessels to $1,100,000 each.

The total of these figures more than exhausts the amount of the appropriation—$3,500,000. The limit of cost fixed by the Bureau for the 5,300-ton vessel is $1,800,000, and of the 7,500-ton, $3,500,000. The practice cruiser authorized by this act will be about 800 tons, armored and carrying a battery of rapid-fire guns. Plans for this vessel are well under way, and will soon be completed.

The Bureau of Construction and Repair, the Chief states, is at work on plans for the vessels authorized by the act of March 2, 1889, which appropriated $4,055,000 for construction purposes besides $140,000 for four steam tugs. Bids for these tugs have just been opened, but the contracts are not let.

The principal vessel provided for in this last act is the armored submerged cruiser monitor, known as the Thomas ship, its general design having been suggested by ex-Congressman Thomas of Illinois. Plans for it are nearly completed, and it is estimated to cost $1,500,000. Two steel cruisers or gunboats, estimated to cost $350,000 each, will be 1,200 tons each, carrying batteries of rapid-fire guns. Plans for these are well under way.

There were also provided for in the act of 1889 a harbor ram of the plan designed by Admiral Ammen, and a dynamite cruiser of the *Vesuvius* type. Nothing has yet been done toward the construction of these vessels. The cruiser is estimated to cost $350,000, but no estimate is made upon the ram.

All of these vessels, for which the plans have been completed, have been described in our columns from time to time.

THE "CONCORD" AND "BENNINGTON."

It may be mentioned here, however, that the engines of the *Concord* and the *Bennington*, which have just been completed at the Quintard Iron Works in New York, are excellent specimens of American practice in this respect. Each of these vessels has two triple-expansion engines,

with cylinders of 22-in., 31-in., and 50-in. diameter and 30-in. stroke. The engines are placed in separate water-tight compartments, the arrangement being such that the low-pressure cylinder is forward in the forward and aft in the after compartment.

The main steam-valves are of the piston type; those of the high-pressure cylinders are of cast-iron, the others being of composition. There is one valve for the high-pressure, one for the intermediate, and two for each low-pressure cylinder. The valves are worked by a radial valve-gear, and are arranged for a minimum cut-off of 4 per cent. of the stroke in the high-pressure and 5 per cent. in the intermediate and low-pressure cylinders. The cut-offs of all the cylinders are capable of being adjusted independently of each other. The movement of each valve is regulated by a reversing-arm and a radius link. Each engine also has a steam reversing-gear.

The pistons are of steel, 2¼ in. thick at the center and 1¾ in. at the periphery, and each is provided with an adjustable cast-iron wearing-shoe. The piston-rods are of steel, 3¾ in. in diameter. The crosshead runs in guides, bolted to the cylinder at one end and to the bed-plate at the other end. Each crosshead is fitted with cast-steel slippers, lined with white metal. The connecting-rods are of wrought-iron, 64 in. between centers, 4½ in. in diameter at the crank-pin neck, and 3¾ in. in diameter at the cross-head neck.

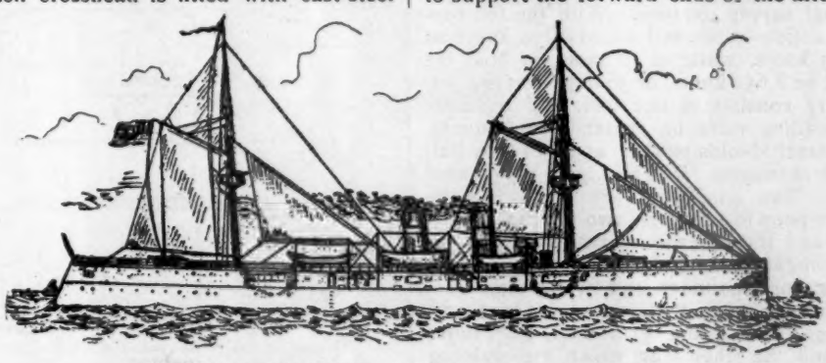
The crank-shafts are of forged steel, fitted with cranks at equal angles, and with the necessary coupling-disks forged on. The crank-webs are 6½ in. thick, except the after one of each engine, which is 7½ in. thick. The crank-pins are 9 in. in diameter and 10 in. long. The webs are shrunk on both shaft and pins and keyed. The shaft journals are 9 in. in diameter and have a total length of 68 in. for each engine. The crank-shaft boxes are of composition, with steel caps, both lined with white metal. The castings containing the crank-shaft bearings are cast-steel in one piece for each engine. They are bolted to engine keelsons and stayed to the cylinders by tie-rods and the guides.

In the forward engine-room is a centrifugal pump, driven direct by its engine, and arranged for freeing the ship from water in case of necessity. The air-circulating and bilge pumps are driven independently of the main engines. Each circulating-pump is arranged with bilge as well as sea injection, and with a suitable by-pass valve. Each air-pump delivers into a feed-tank placed in the forward engine compartment. This tank has a capacity of about 300 gallons, and is partitioned and fitted as a filter. The shells of the condensers are cylindrical and made of brass. They are fitted with brass tubes ⅝ in. in diameter outside, and each has a cooling surface of about 2,450 sq. ft. measured on the outside of the tubes. The tubes are placed fore-and-aft, and the water can circulate through them and hence overboard through outboard delivery-valves. There are also two vertical duplex pumps fitted in each fire-room of ample capacity for feeding the boilers. One set in each fire-room is fitted to draw from feed-water tank and bottom of forward condenser and discharge through the boiler check-valves. The second set in each fire-room is fitted to draw water from the tank, sea, bilge and boilers, and discharge into the fire-main through the boiler-checks and overboard.

There are four cylindrical horizontal tubular steel boilers, containing an aggregate grate surface of 220 sq. ft. arranged fore-and-aft in two water-tight compartments, each with a fire-room athwartship and abaft the after boilers and forward of the forward boilers. Each boiler is 9 ft. 9 in. in diameter and 17 ft. 6 in. long. The shell is 1⅛ in. thick. The top of the smoke-pipe is about 55 ft. above the guards. The fire-rooms are arranged to work under air-pressure, and each is fitted with two blowers, capable of constantly supplying sufficient air. The boilers will carry 160 lbs. pressure.

The line shafting is of steel, 9 in. in diameter; one shaft is 27½ ft. long, and the other is 7½ ft. long, and each has a 4-in. hole bored through it. The propeller-shafts are of steel and are formed of two lengths, the forward one being 22 ft. 7 in. long and from 9½ to 9¾ in. in diameter, and the after one 28 ft. long and 11½ in. in diameter. The former has a 4-in. axial hole and the latter a 7-in. hole reduced to 4 in. at the after end. The steel tubes for the reception of the propeller-shafts are located on each side of the ship, as shown in the plan view. The forward tubes are built in the framework, which is bossed out in a suitable manner to support the forward ends of the after tubes, their after ends being supported by struts. The propellers are of manganese bronze, 10½ ft. in diameter, with adjustable blades, right and left hand.

The distilling apparatus consists of one evaporator and distiller capable of furnishing 2,000 gallons of potable water in 24 hours. The vessels will be lighted throughout by electricity.



THE PROPOSED 3,000 TON CRUISER.

THE 3,000-TON CRUISERS.

These cruisers, to which some reference has been made heretofore, are described as follows by the Bureau of Construction. They have not yet been named, but are officially designated as cruisers No. 7 and 8. They will be twin screw ships, with heavy protected deck, very great speed and heavy batteries of rapid-fire guns. They have poop and forecastle decks, with an open gun-deck between and bridges along the tops of the hammock nettings connecting the poop and the forecastle.

The principal dimensions are: Length on load line, 300 ft.; breadth, extreme, 42 ft.; mean draft, 18 ft.; displacement, 3,183 tons; tons per in., 20; indicated H. P., 10,000; speed in knots, 20.

The rudder is of a balanced type and is made to form a continuation of the lines of the ship aft. This type is much in favor abroad at present, and it will interest Americans to learn that such a rudder was placed on the Stevens battery.

The protective deck slopes at the sides in two slopes of 22° and 39°. It is first covered with plating ½-in. thick, and a 2-in. plate is worked on this on the slopes amidships, reduced to 1½ in. at the ends, and a ½-in. plate is worked on the horizontal part, making the deck's total thickness 2½ in. on the slopes amidships, 2 in. on the slopes at the ends, and 1 in. on the flat.

A coffer dam is worked along in wake of the water-line next the outside plating in the coal bunker on the slope of the protecting deck. This will be filled with woodite.

The engines are triple-expansion, vertical, inverted, and direct-acting, with a high-pressure cylinder 36 in., an intermediate 53 in. and two low-pressure 57 in. in diameter,

the common stroke being 33 in. The collective H. P. of the propelling, air-pump, and circulating engines is 10,000 at 164 revolutions. The condensers have each 7,000 ft. of cooling surface. There is a double, vertical, single-acting air-pump, worked by a vertical compound engine for each engine. The circulating pumps are centrifugal, one for each condenser worked independently.

There are four double-ended boilers and two single-ended boilers to be used as auxiliaries, placed in four water-tight compartments. Two of the main boilers are 13 ft. 4 in. in diameter and 20 ft. 3½ in. long, the other two main boilers are 14 ft. 6½ in. in diameter and 20 ft. 3½ in. long. The two auxiliary boilers are 11 ft. 2 in. in diameter by 9 ft. 0½ in. long. The working pressure is 160 lbs. The total heating surface is 19,382 sq. ft. and the grate surface 597 sq. ft.

The forced draft system consists of a blower discharging into a main duct under the fire-room floors, from which a branch duct is led to the ash-pit of each furnace, means being taken for closing the ash-pits when under forced draft and to prevent the leaking of gases out of the furnace doors.

The bunker capacity of coal for these vessels will be 556 tons, and the normal supply 400 tons. With the full supply, the radius of action at the full speed of 20 knots an hour, will be 1,243 knots, while at 10 knots an hour the cruising range will be 8,652 knots, or 36 days' voyage.

The main battery consists of one 6-in. and ten 4-in. rapid-fire, breech-loading rifles on center pivot mounts, protected by thick steel shields worked as part of the hull or made fast to the carriages. The 6-in. gun is mounted on the forecastle. Two 4-in. guns are placed on the poop, two under the poop in sponsons, two under the forecastle in sponsons, and the other four—two on a side—in sponsons. The secondary battery consists of two 6-pounders, two 3-pounders, one 1-pounder, and two 37 mm.

There are six torpedo tubes with openings about 4 ft. above the water, worked from the berth deck, fixed tubes forward and aft, and the other four, which are training tubes, are placed at the sides on the forward and after berth decks. The tubes are of the Howell pattern, using gunpowder impulse—a device much superior to the hydraulic or pneumatic telescopic rammer sometimes used.

The rig is that of a two-masted schooner spreading 7,210 sq. ft. of sail. The masts have barbette galleries for machine guns just below the tops. The boats are all stowed inboard out of the line of the fire of the guns, on skid beams.

These vessels will be provided with a complete electric light plant, including three search-lights. There will be two engines and two dynamos, so arranged that either dynamo can be connected with all or any of the circuits, so that there will be no loss of light in case of accident. A full system of ventilation, worked by blowers, is provided in addition to the usual circulating pumps, etc., and the quarters for officers and men will be more convenient than in some of the new vessels.

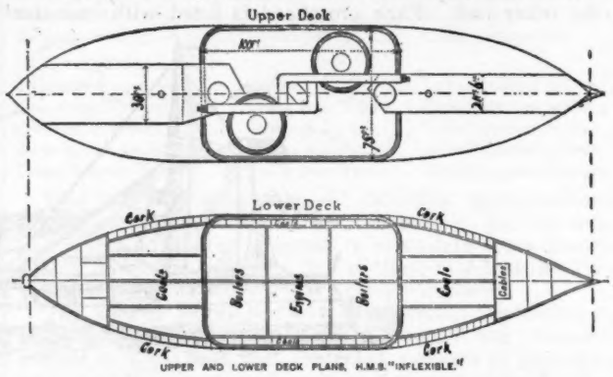
These 3,000-ton cruisers will be of a very similar type or class to the French ships of the *Davoust* type, and the English cruisers of the *Magicienne* class, both of which have been illustrated in our columns.

Bids for these vessels and for the 2,000-ton cruisers (which were illustrated in the July JOURNAL) were to be received until August 22. A number of bids, it is understood, have been sent in, but no result has been announced.

THE ENGLISH BATTLE-SHIP "INFLEXIBLE."

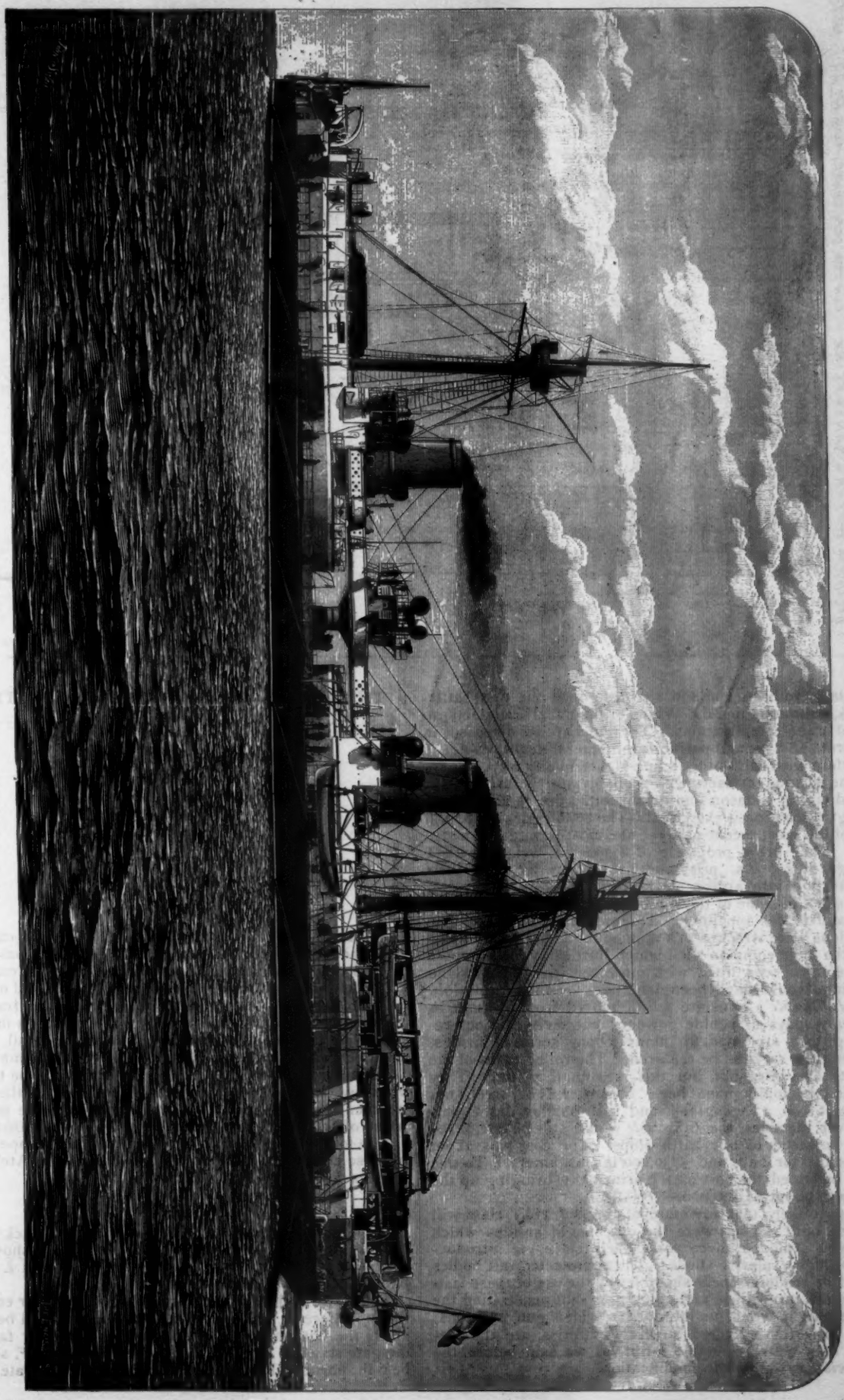
(From the London *Engineer*.)

THE accompanying illustration is a general view of the *Inflexible*, which is known in the English Navy as an armored turret battle-ship of the first class. It is described by Mr. W. H. White, Director of Naval Construction, as a "central citadel ship with turrets placed *en echelon*." It was built at Portsmouth and launched in 1876, but not actually completed till 1881, just in time to take part in the bombardment of the forts at Alexandria a year afterward. The engines were made by Elder & Company, and are 8,010 indicated H. P. The principal dimensions of the ship are as follows: Length, 320 ft.; beam, 75 ft.; extreme draft, 26 ft. 4 in.; displacement, 11,880 tons; speed, 13.80 knots; coal capacity, 1,300 tons. The leading characteristic in the structure of this vessel, which is quite a typical example of its class, is a huge central citadel protected by a belt and bulkheads of iron armor plates, 16 ft. high and 110 ft. in length, placed immediately over the engines and boilers, the turrets being superimposed upon a thin armored deck covering the whole. This armor is 24 in. thick in the center, thinning to 20 in. at the top and 16 in. at the bottom. Practically, it is not so strong as the sides of the *Trafalgar's* "womb," which has 18 in. of compound steel-faced armor upon it. The *Inflexible* has a raft body at either end, entirely unprotected with plating, except that a thick iron deck extends from the citadel to stem and stern, at a considerable depth below the surface of the water, which covers the magazines. These raft-body ends are made—presumably (?)—buoyant by a series of thick compartments filled with cork, and stretching over half of the unprotected ends. The unprotected ends of the ship have an actual freeboard of the same weight as the top of the armor plates, and are necessarily low, so as to admit of the firing of the heavy turrret guns along their surfaces; but the superstructure gives an erroneous impression of the height of the *Inflexible*, and makes it appear as though she has a high bow. As a matter of fact, owing to her short length and considerable beam, the fore-deck outside the cabins is all a-wash in heavy weather. The central citadel has further protection, behind the armor plates and teak backing, of large coal bunkers disposed within its whole length. There is a spar deck over the superstructure at both ends, upon which boats are housed and light armament mounted. The turrets are covered with 17-in. composite armor, and each pair of guns on either side can train through an arc of 180°, so as to fire ahead, astern, or abeam. The arrangement of the guns for loading is execrable. The hydraulic machinery is so arranged that the muzzles of the guns are depressed to an opening in the deck below, immediately over the center of the vessel, and while in this loading position they point directly into the main magazines. A premature discharge under these circumstances would absolutely imperil the security of the ship. This was a fatal oversight in the construction of the *Inflexible*. The danger attaching to such badly protected ends as she possesses was also strikingly exemplified at Alexandria, where an officer was killed just outside the citadel, although below at the time, and where the ship was hulled effectively several times, though it is needless to say the citadel was not penetrated.

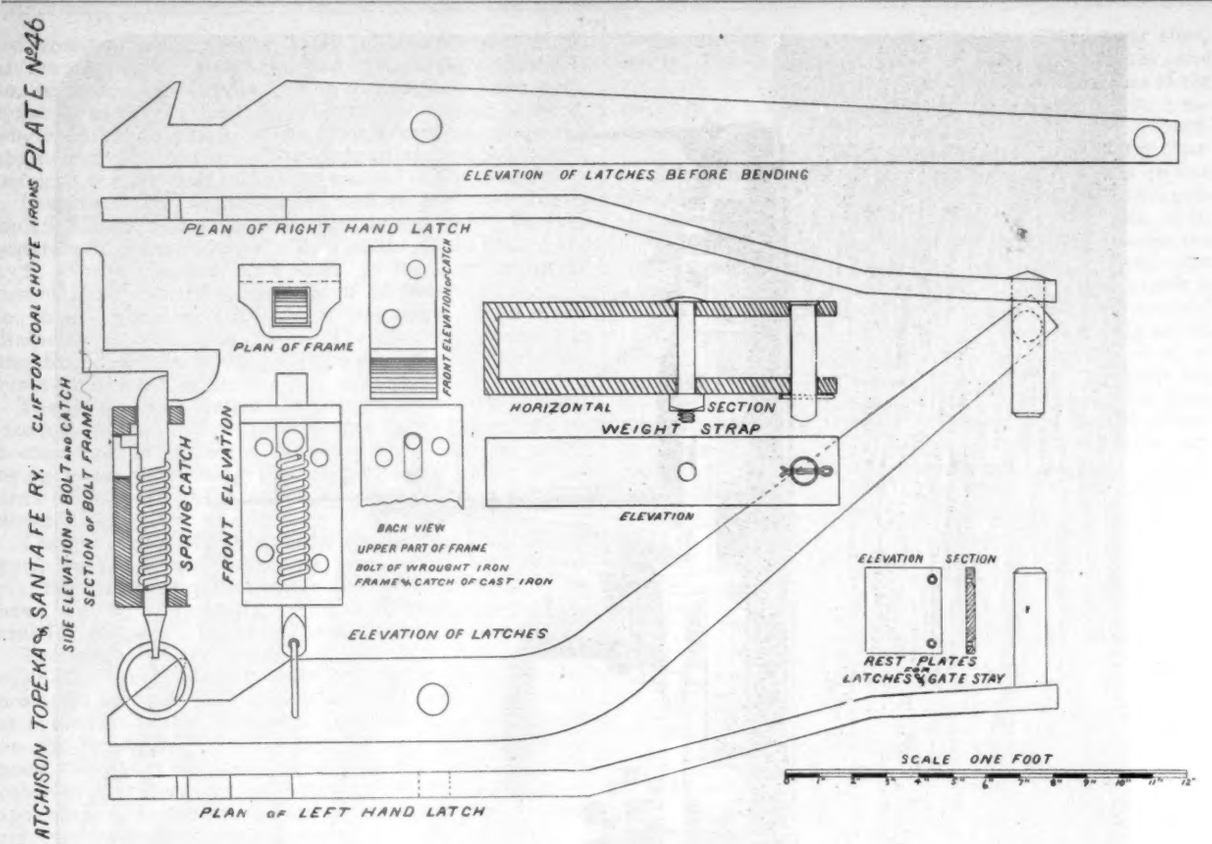


UPPER AND LOWER DECK PLANS, H.M.S. "INFLEXIBLE."

The armament of the *Inflexible* consists of four 16-in., 80-ton muzzle-loading guns in the two turrets, and eight 4-in. breech-loading steel guns, and 21 G. F. and machine guns within and upon the superstructure. The 4-in. guns are an afterthought. They do not form a properly constituted auxiliary battery, as they are not contained in protected stations of any sort. Moreover, there is no proper room for them, and in some cases they would interfere with the fighting of the turret guns, if rapid fire were being carried on in the heat of action. Most ingenious arrange-



THE ENGLISH BATTLE-SHIP "INFLEXIBLE."


ATCHISON TOPEKA & SANTA FE RY. CLIFTON COAL CHUTE IRONS PLATE No 46
SIDE ELEVATION OF BOLT AND CATCH
SECTION OF BOLT FRAME
ELEVATION OF LATCHES BEFORE BENDING
PLAN OF RIGHT HAND LATCH
PLAN OF FRAME
FRONT ELEVATION OF CATCH
HORIZONTAL SECTION
WEIGHT STRAP
ELEVATION
SPRING CATCH
FRONT ELEVATION
BACK VIEW
UPPER PART OF FRAME
BOLT OF WROUGHT IRON
FRAME & CATCH OF CAST IRON
ELEVATION OF LATCHES
ELEVATION SECTION
REST PLATES FOR LATCHES & GATE STAY
SCALE ONE FOOT
PLAN OF LEFT HAND LATCH

ments have been made in the designs of the new battle-ships, submitted by Mr. White to the naval architects, to avoid these complications. The guns are so disposed, in separate and remote positions, on several decks, as not to interfere with each other's line of fire in any way. Some of the existing cruisers will probably aim point blank at an adjoining sponson gun during rapid fire in action, unless great caution is exercised. The 80-ton guns, although not of the most recent pattern, are most formidable weapons. They fire a projectile of 1,700 lbs. weight, with a charge of 450 lbs. prismatic brown powder, and their penetration into armor plate at 1,000 yards is 23.3 in. The effect of some of these projectiles striking the forts at Alexandria was appalling. At Fort Ras-el-tin whole gun positions were wrecked in a moment by a single shot; and had the huge common shell which hurtled over the houses in the town been fitted with more sensitive fuses, whole districts would have been laid bare by their explosion. The *Inflexible's* guns are a little scored from ill-usage in the early days of pebble powder; but, even without retubing, they are good for many a long series of firings, should their services be required. The roller paths of the turrets are worn out, but this is a small matter. They should originally have been constructed of steel, not wrought iron. Re-engined, and with shallow light plating over the sides, the *Inflexible* would still be one of the most powerful of our battle-ships. The cost was about $3,240,000 for hull, and $730,000 for machinery. To this must be added the cost of the armament, bringing up the whole to about $4,500,000.

It is unlikely that any more of the *Inflexible* class will ever be built. They were the outcome of an idea which has been exploded, more particularly since the introduction of high-explosive shells. The unprotected raft bodies would be rendered mere shambles by the use of these last-mentioned projectiles, and one single shot penetrating the citadel might wreck its interior. Divided gun positions, with powerful protected auxiliary batteries, are the outcome of a better principle. But, as we said before, the *Inflexible* is well worth modification.

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C. E.

(Copyright, 1889, by M. N. Forney.)

(*Continued from page 376.*)

CHAPTER XIII.

COAL-CHUTES (*Continued*).

Plates 46, 47, and 48 show in detail all the special iron work needed in the construction of the Clifton Coal-Chute as built by the Atchison, Topeka & Santa Fé Railroad.

Plates 49 and 50 show sections of the chutes and method of operating. Plate 51 shows front elevation and framing. As the dimension of each piece of timber used is marked on the plans, and as everything is shown in detail, it has not been considered necessary to add a bill of material. One objection to any one bill of material would be that in very few cases are any two coal-chutes built of the same number of pockets, and that, outside of the chute proper, many of the details must be changed for local reasons.

The following directions for the erection and operation of these chutes are taken from the plans of the Atchison, Topeka & Santa Fé Railroad.

DIRECTIONS.

Set the center of the apron hinges *N N* 3 in. back of the face of the chute building posts, at the height shown on the plan. Set the center of the gate latch post *L* 16 in. back of the face of the chute building posts.

The gate *G* should be hung so that the lower edge of the inner face of the gate when hanging free will be ¼ in. above the bottom of the pocket, and the exterior face of the gate stay bar pivot, *E*, and gate latch plate *F*, should be 6 in. horizontally in front of the center of the gate latch

ATCHISON TOPEKA & SANTA FE RY. CLIFTON COAL CHUTE IRONS

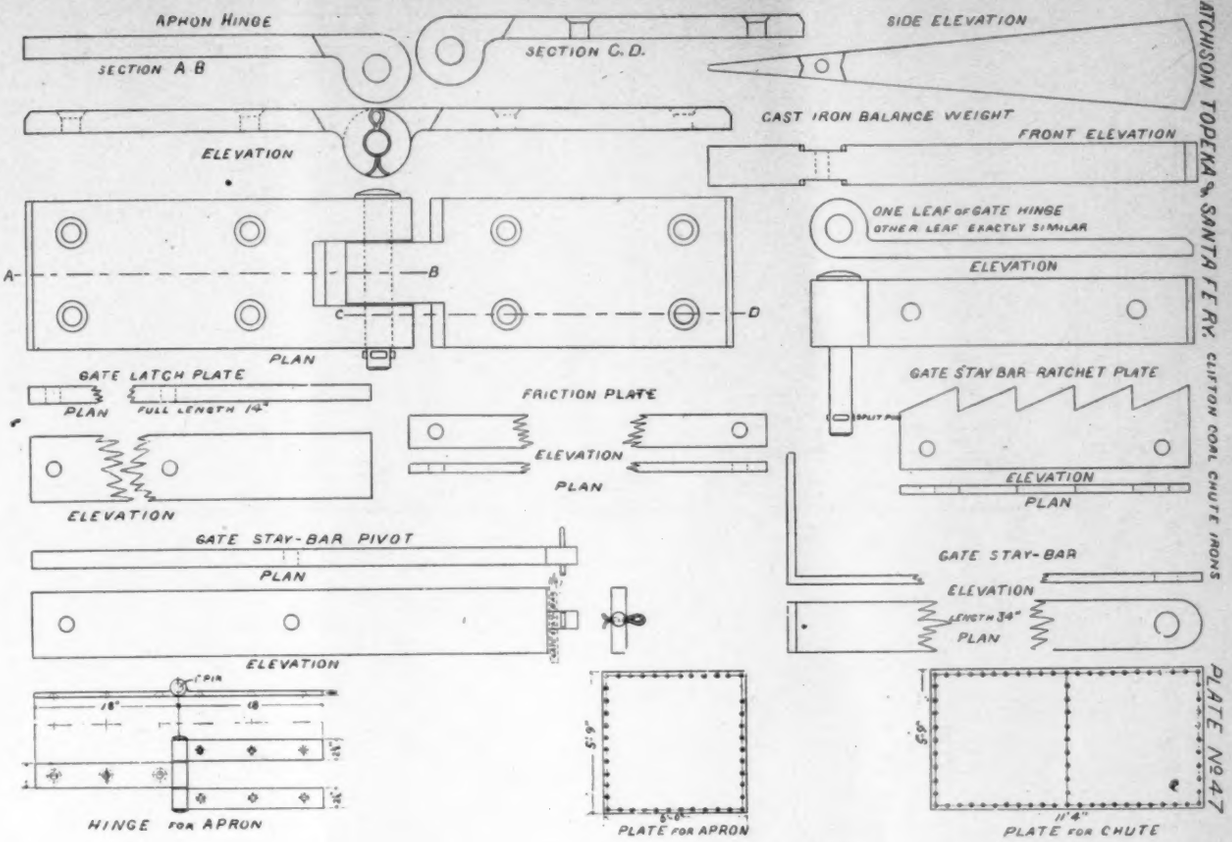


PLATE No. 47.

CLIFTON COAL CHUTE.

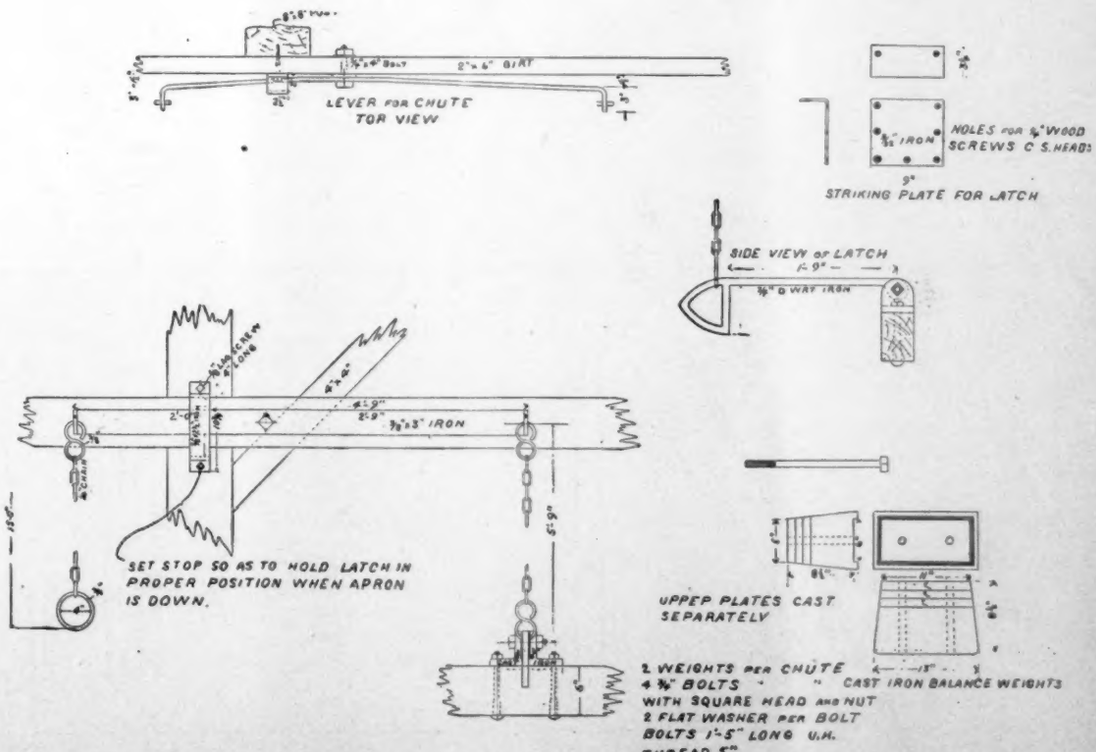

LEVER FOR CHUTE
FOR VIEW
HOLES FOR ¾" WOOD SCREWS C S. HEADS
STRIKING PLATE FOR LATCH
SIDE VIEW OF LATCH
SET STOP SO AS TO HOLD LATCH IN PROPER POSITION WHEN APRON IS DOWN.
UPPER PLATES CAST SEPARATELY
2 WEIGHTS PER CHUTE
4 ¾" BOLTS " " CAST IRON BALANCE WEIGHTS
WITH SQUARE HEAD AND NUT
2 FLAT WASHER PER BOLT
BOLTS 1'-5" LONG U.H.
THREAD 5"

PLATE No. 48.

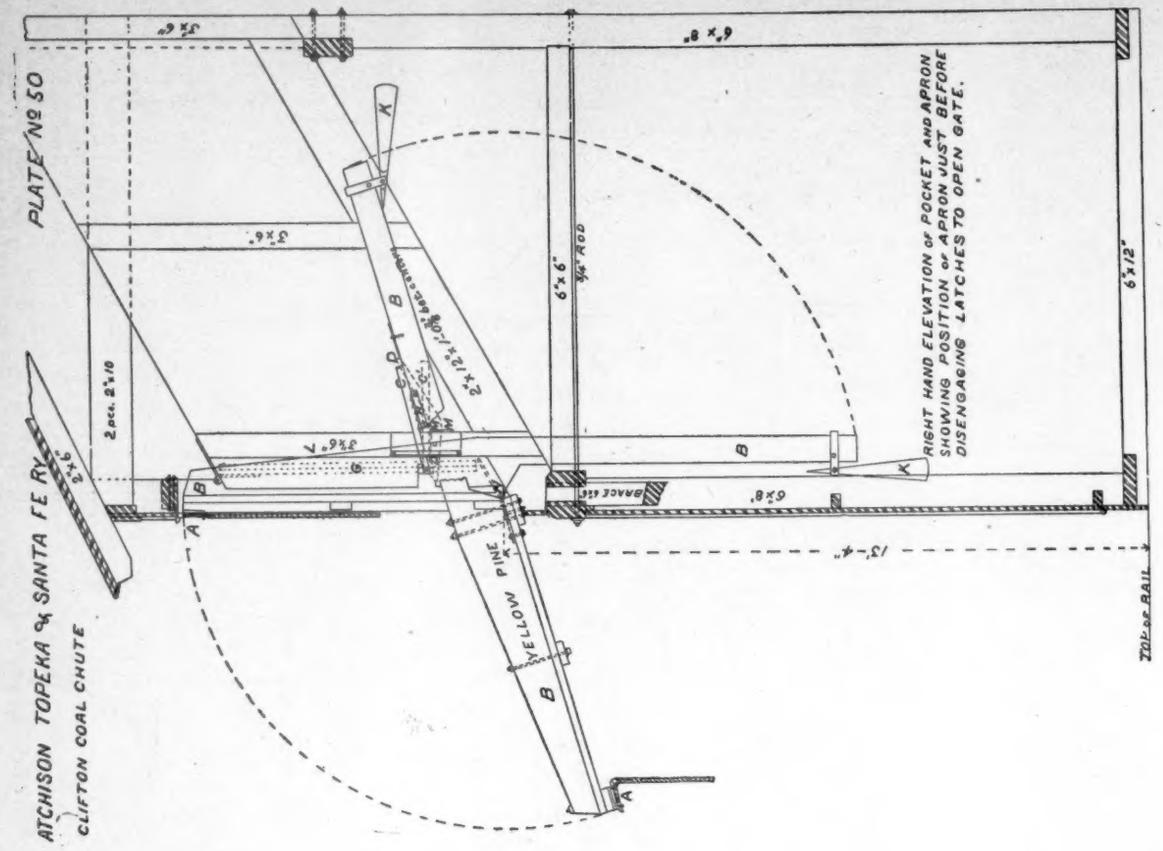


PLATE No 50
ATCHISON TOPEKA & SANTA FE RY.
CLIFTON COAL CHUTE
RIGHT HAND ELEVATION of POCKET AND APRON
SHOWING POSITION of APRON JUST BEFORE
DISENGAGING LATCHES TO OPEN GATE.
YELLOW PINE
13'-4"
TOP of RAIL

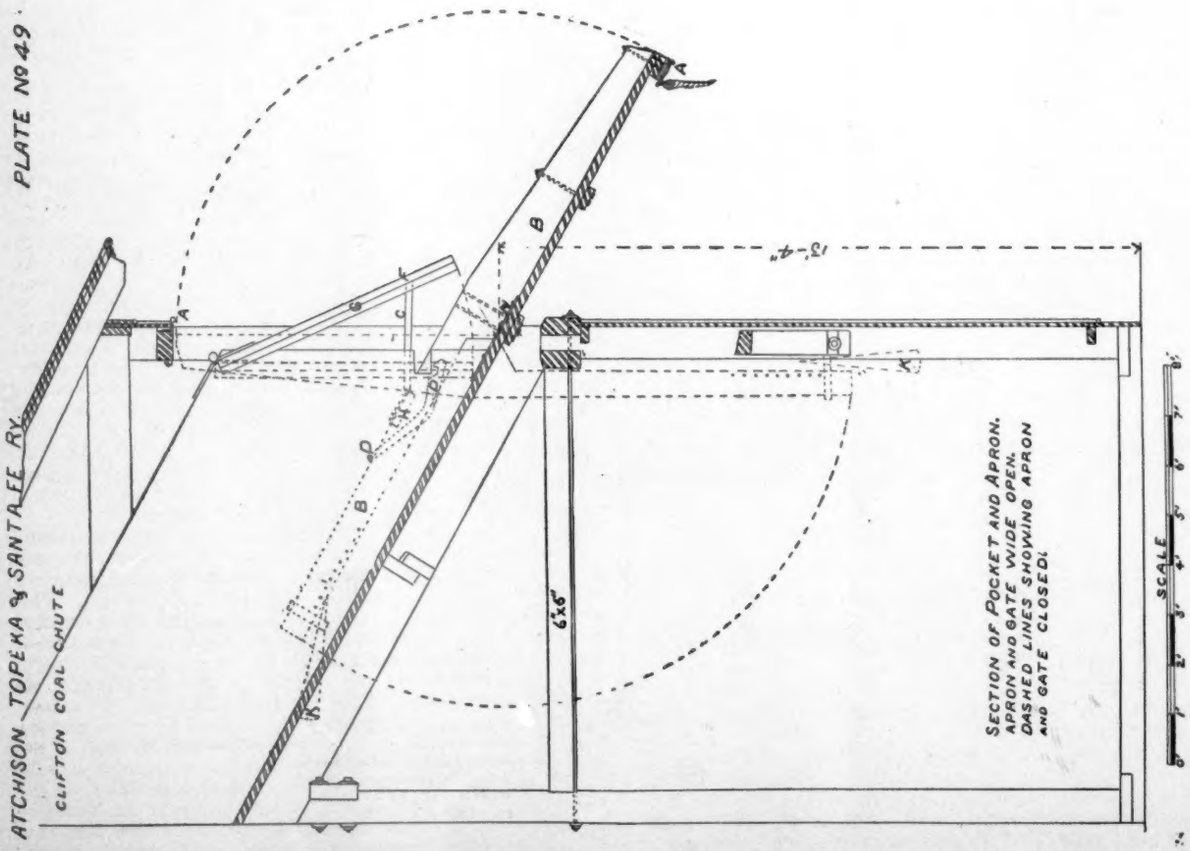
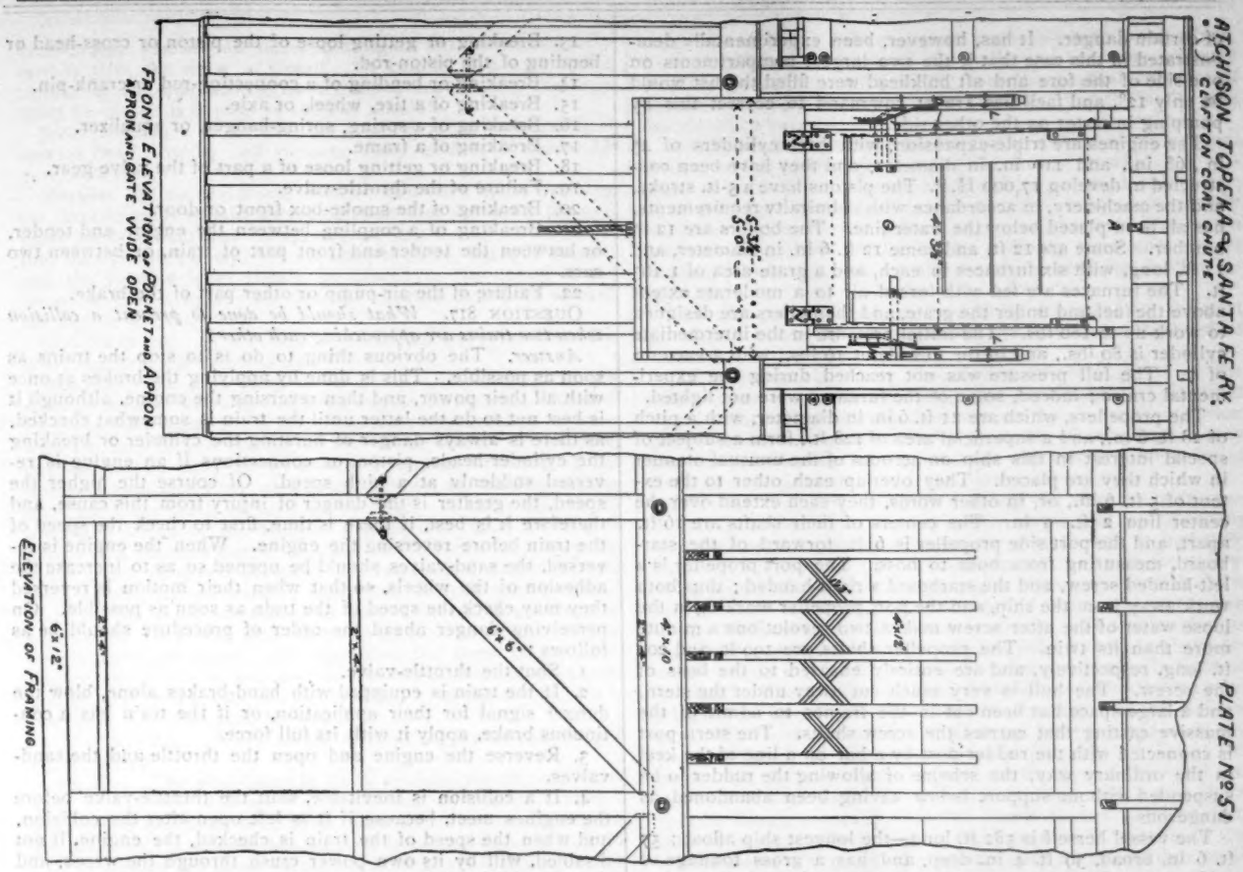


PLATE No 49
ATCHISON TOPEKA & SANTA FE RY.
CLIFTON COAL CHUTE
SECTION OF POCKET AND APRON.
APRON AND GATE WIDE OPEN.
DASHED LINES SHOWING APRON
AND GATE CLOSED.
SCALE
13'-4"


ATCHISON TOPEKA & SANTA FE RY.
CLIFTON COAL CHUTE
FRONT ELEVATION OF POCKET AND APRON
APRON AND GATE WIDE OPEN
ELEVATION OF FRAMING
PLATE No. 51

post, the centers of the pivots and latch being placed 1 ft. above the bottom of the gate. The centers of the bolts on which the gate latches turn should be placed in the center of the gate latch post, and 1¼ in. below the center of the gate stay bar pivot. The rest plate, *M M*, should be set so as to hold the stay bar and latches in the positions *C'* and *D D*, respectively, in Plate 50.

THE OPERATION.

The pocket being charged, and the apron and gate in position—as shown by the dotted lines on Plate 49, and by the hair lines and dotted lines on Plate 50—by means of the rope attached to the spring catch *A*, disengage the bolt and pull down the apron *B B* to the position indicated in Plate 50, which will carry the gate stay bar *C* from *C'* to *C* (Plate 50), and catch the handles of the latches *D D*; upon still farther depressing the apron, the latches will be disengaged from the gate stay bar pivot *E*, and the gate latch plate *F*, when the pressure of the coal will open the gate *G* to the position shown in Plate 49, or some intermediate position; the bent arm of the gate stay bar engaging with the ratchet plate *H*, and holding the gate open so long as the apron is kept in the position shown in Plate 49. When the coal is discharged, the apron being loosed will return to its original position by the action of the cast-iron balance weight *K*; the latches and gate stay bar resting upon the rest plates *M M*.

(TO BE CONTINUED.)

The Largest Merchant Steamer.

(From the London *Times*.)

THE new steamship *Teutonic* of the White Star Line arrived at Liverpool on Monday, after her first trial cruise. She is characterized by several novelties, and is especially interesting on account of her being the first merchant vessel built to comply with the conditions of an Admiralty subsidy. As she is to take part in the review of the fleet at Spithead on Saturday, she is fitted with four of her complement of 12 guns. They are of the type commonly known as 5-in. guns, having a range at extreme elevation of over five miles. The charge consists of a cartridge of 12 lbs. and a steel-forged shell of 45 lbs., containing a bursting charge of 2 lbs. A shot of 200 yards should penetrate a 5-in. plate of wrought iron; and it is estimated that half the shots fired should hit a target less than a yard square at a mile distant. The guns are to be placed six on either side upon the promenade deck, and those at present in position are fixed at the extremities of the ship.

The vessel has been built by Messrs. Harland & Wolff for Messrs. Ismay, Imrie & Company, and may be regarded as absolutely the safest ship afloat. She is fitted with twin screws, and the whole of the machinery, engines, boilers, and coal for working either screw is shut off completely from its neighbor by a fore and aft bulkhead, which extends from the after end of the engine-room to the forward end of the foremost coal bunker, and, in fact, intersects the six largest of the 12 watertight compartments made by the 11 ordinary transverse bulkheads. This fore and aft bulkhead is pierced by only one locked door, the key of which is held by the chief engineer. The doors between the engine-rooms and the stokeholes are in every instance duplicated, and the duplicate door is in every case under the control of the captain on deck. When liberated they close by their own weight, but by an ingenious contrivance their descent is freed from violence. Ascending from the door is a rod surmounted by a piston, which works in a cylinder 4½ in. in diameter filled with glycerine. When the door is allowed to descend the whole of this glycerine has to pass through a hole in the piston, and the sluggish liquid thus prevents a rapid and dangerous descent of the massive door.

There is, however, another and more interesting novelty about these doors. In the event of water flowing into the ship the doors will close automatically. As the water rises in the bilge it will buoy up a hollow piston attached to a rod. This rod, on being pushed up about a foot, removes the catch that holds the door, and it might chance that the first information of danger in the engine-room would be the automatic closing of these protective doors. The principle is common enough. It is merely an adaptation of the domestic ball cock; but, assuming the buoyancy sufficient for the work to be done, nothing could be more certain in its action. The introduction of the fore and aft bulkhead dividing the separate engines of a twin-screw ship has been objected to by high authorities, on the ground that if one side were filled with water the list would be so great that the vessel would inevitably overturn, and that what was conceived as a means of safety would become a source

of certain danger. It has, however, been experimentally demonstrated in this case that if the two largest compartments on one side of the fore and aft bulkhead were filled the list would be only 12°, and facilities are at command to correct this by pumping in water on the other side.

The engines are triple-expansion, with three cylinders of 43 in., 68 in., and 110 in. in diameter, and they have been constructed to develop 17,000 H.P. The pistons have a 5-ft. stroke, and the machinery, in accordance with Admiralty requirements, has all been placed below the water-line. The boilers are 12 in number. Some are 12 ft. and some 12 ft. 6 in. in diameter, and 17 ft. long, with six furnaces in each, and a grate area of 1,163 ft. The furnaces are fed with forced air to a moderate extent above the fuel and under the grate, and the boilers are designed to work up to 180 lbs. The initial pressure in the intermediate cylinder is 80 lbs., and in the low about 16 lbs., with a vacuum of 7. The full pressure was not reached during the experimental cruise; indeed, some of the furnaces were not lighted.

The propellers, which are 21 ft. 6 in. in diameter, with a pitch of 28 ft. 6 in., and a superficial area of 128 ft., form a subject of special interest in this ship on account of the unusual manner in which they are placed. They overlap each other to the extent of 5 ft. 6 in., or, in other words, they each extend over the center line 2 ft. 9 in. The centers of their shafts are 16 ft. apart, and the port side propeller is 6 ft. forward of the starboard, measuring from boss to boss. The port propeller is a left-handed screw, and the starboard a right-handed; thus both work away from the ship, and the port propeller working in the loose water of the after screw makes two revolutions a minute more than its twin. The propeller shafts are 199 ft. and 205 ft. long, respectively, and are entirely encased to the boss of the screw. The hull is very much cut away under the stern, and a large space has been cut in the frames to admit of the massive casting that carries the screw shafts. The stern post is connected with the rudder-post by a bar on a line of the keel in the ordinary way, the scheme of allowing the rudder to be suspended without support below having been abandoned as dangerous.

The vessel herself is 582 ft. long—the longest ship afloat; 57 ft. 6 in. broad, 39 ft. 4 in. deep, and has a gross tonnage of 9,685 tons. She has a cutter stem, and, relying wholly on her two sets of engines, the masts are little more than three bare poles without yards. Thirty feet up the foremast is a sort of crow's nest for the lookout.

Accommodation is provided for 300 first-class, 150 second, and 750 steerage passengers. She has a promenade deck 245 ft. long, with a clear way of 18 ft. on each side of the deck-houses. Some portion of this promenade is covered by an awning deck, which is used for stowing the boats.

For the fittings and decorations throughout the boat, it must suffice to say that they are unusually lavish, even in these days of sumptuous ocean traveling.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

By M. N. Forney.

(Copyright, 1887, by M. N. Forney.)

(Continued from page 383.)

CHAPTER XXXIV.

ACCIDENTS TO LOCOMOTIVES.

QUESTION 816. *What are the most serious accidents which may happen in running a locomotive?*

Answer. The most serious accidents are:

1. Collision of two trains approaching each other.
2. Collision of a moving with a standing train.
3. Collision of trains at the crossing of two railroads.
4. Running a train into the opening left by an open draw-bridge.
5. Escape of an engine without any one on it.
6. Running off the track.
7. Explosion of the boiler.
8. Bursting or rather collapse of a flue.
9. Overheating and burning of the crown-sheet.
10. Blowing out of a bolt, stud, rivet, cock, or any accident which makes or leaves a hole in the boiler for the escape of steam or water.
11. Failure of the feed-pumps, injector or check-valve.
12. Breaking or bursting of a cylinder, cylinder-head, steam-chest, or steam-pipe.
13. Breaking or getting loose of the piston or cross-head or bending of the piston-rod.
14. Breaking or bending of a connecting-rod or crank-pin.
15. Breaking of a tire, wheel, or axle.
16. Breaking of a spring, spring-hanger, or equalizer.
17. Breaking of a frame.
18. Breaking or getting loose of a part of the valve-gear.
19. Failure of the throttle-valve.
20. Breaking of the smoke-box front or door.
21. Breaking of a coupling between the engine and tender, or between the tender and front part of train, or between two cars.
22. Failure of the air-pump or other part of the brake.

QUESTION 817. *What should be done to prevent a collision when two trains are approaching each other?*

Answer. The obvious thing to do is to stop the trains as soon as possible. This is done by applying the brakes at once with all their power, and then reversing the engine, although it is best not to do the latter until the train is somewhat checked, as there is always danger of bursting the cylinder or breaking the cylinder-heads, piston, or connections if an engine is reversed suddenly at a high speed. Of course the higher the speed, the greater is the danger of injury from this cause, and therefore it is best, if there is time, first to check the speed of the train before reversing the engine. When the engine is reversed, the sand-valves should be opened so as to increase the adhesion of the wheels, so that when their motion is reversed they may check the speed of the train as soon as possible. On perceiving danger ahead the order of procedure should be as follows:

1. Shut the throttle-valve.
2. If the train is equipped with hand-brakes alone, blow the danger signal for their application, or if the train has a continuous brake, apply it with its full force.
3. Reverse the engine and open the throttle and the sand-valves.
4. If a collision is inevitable, shut the throttle-valve before the engines meet, because if it is left open after the collision, and when the speed of the train is checked, the engine, if not disabled, will by its own power crush through the wreck, and thus do additional damage.

To the credit of locomotive engineers, it can be said that they rarely leave their engines, no matter how imminent the danger is, until after they have applied all the means of checking the speed of the train. If a violent and dangerous collision is inevitable, then an engineer may protect himself by jumping from his engine, or remain on it as may seem best: but he is in duty bound to do all in his power to prevent dangerous collisions, especially if he is running a passenger train.

QUESTION 818. *What kind of collisions occur oftenest?*

Answer. What are called "tail-end collisions"—that is, collisions of trains which run in the same direction, although there are unfortunately many collisions of trains running in opposite directions, or "butting collisions," as they are called.

QUESTION 819. *What should be done if another train is approaching a standing train, and there is danger of a collision?*

Answer. The locomotive runner of the standing train should start his engine in the same direction as the approaching train is running as quickly as possible, because the shock of the collision will be very much lessened if both trains are moving in the same direction compared with what it would be if one was standing still.

QUESTION 820. *What should be done to avoid a collision at a railroad crossing?*

Answer. If there are no interlocking and distant signals at the crossing, trains should always come to a dead stop before crossing another railroad on the same level.

If there are interlocking and distant signals, the engineer should be absolutely sure that they indicate to him that the crossing is clear. If by reason of fog or inadvertance in looking for the signals or *any other reason* he has the slightest doubt about the position of the distant signal, he should slack up when he passes it so as to be able to stop before he reaches the home signal at the crossing. If, however, through any cause danger of a collision should be incurred at a crossing, then evidently the one train should be stopped and the other moved out of the way as soon as possible. It is a safe rule for all persons, as well as locomotive engineers, to adopt, *never to cross a railroad without first stopping to see whether the road is clear.* If those who drive horses as well as those who drive locomotives, and also foot travellers, would scrupulously observe this rule, many lives and much suffering would be saved each year.

QUESTION 821. *How can an accident by running into the opening at a draw-bridge be avoided?*

Answer. The precautions to be taken are very much the same as those which should be observed at crossings. It is a safe rule ALWAYS to come to a dead stop before reaching a

draw-bridge, and second, never start again until it is absolutely certain that the draw is closed. Of course if a locomotive runner of an approaching train finds a draw open, the only thing he can do is to stop as soon as possible.

QUESTION 822. *What measures should be taken to prevent locomotives from escaping and running away without a responsible person on them?*

Answer. In the first place, when a locomotive is left standing the throttle-valve should always be *closed* and *fastened;* the cylinder cocks should also be opened, so that if any steam leaks into the cylinders it will not accumulate there, but will escape, and the reverse lever should be placed in the center of the sector, so that if by any accident the throttle should be opened the engine will not start.

QUESTION 823. *If a locomotive should escape, what should be done, and how may it be captured?*

Answer. The firs thing to be done is to telegraph to the stations toward which the escaped engine is running, either to keep the track clear, or, if there is a train approaching, to open a switch, and thus let the engine run off the track. An escaped engine may be captured by a swifter engine following it, but this is always attended with great danger, as the first engine may leave the track or become wrecked. A safer plan is to telegraph ahead of the escaped engine, and have an engine placed in a position where the track can be seen for a long distance in the direction in which the runaway is expected. As soon as the latter comes in sight, the waiting engine should start in the same direction, so that when they get near to each other they will both be running the same way and at nearly the same speed. By regulating the speed of the front engine, the following one may be allowed to come up to it quite gently, and then a man can easily climb from the one engine to the other, and thus both be stopped.

QUESTION 824. *What should be done in case an engine gets off the track?*

Answer. The first thing to do is to close the throttle-valve and "signal for brakes," * or apply the continuous brakes if the train is equipped with them, and then reverse the engine. As soon as the engine has stopped it should be seen that the proper signals are given to protect it from approaching or following trains. If the boiler is in such a position that the heating surfaces are liable to be uncovered with water, they may get red hot and be burned. If there is danger of this the fire should be either drawn, quenched with water, or extinguished by covering it with sand, gravel, earth, sod, or snow, and then wetting the covering.

QUESTION 825. *How is a locomotive replaced on the track in case it gets off?*

Answer. If the engine is still standing on its own wheels, and has not gone far from the rails, it can usually run itself back by the aid of hydraulic jacks, wrecking frogs, or blocking under the wheels. Generally it can be replaced on the track best by running it the reverse direction to that in which it ran off. Often a derailed engine can be put back with the aid of another engine when it could not run itself back. It is impossible to give any directions for replacing locomotives on the track which will meet the great variety of circumstances which occur in practice. If an engine has fallen on its side or has run down an embankment, it is usually necessary to send for the appliances which are now provided on nearly all roads for removing wrecks and replacing engines on the track. These appliances are generally stored in what is called a wrecking or tool car, which is placed at a convenient point on the road, from which it can be sent to any place where its services are likely to be needed. Such cars are provided with ropes, jack-screws, chains, crowbars, levers, etc., to be used in such cases, and generally a special set of men is sent with the wrecking car to direct and assist in replacing engines and cars on the track. It would lead us too far to describe all the methods of doing this employed under various circumstances; and as such work seldom forms part of the duties of a locomotive runner, a complete description would be out of place here.

QUESTION 826. *After an accident which disables the engine, what is the first thing to do?*

Answer. The first thing to do is always to "*protect the train;*" that is, to send out signal men in each direction to stop approaching trains; otherwise they might run into the wrecked train, and thus cause a double accident.

QUESTION 827. *What is the chief cause of boiler explosions?*

Answer. The cause of all boiler explosions, as happily expressed by a prominent American engineer,† is THAT THE PRESSURE INSIDE THE BOILER IS GREATER THAN THE STRENGTH OF THE MATERIAL OUTSIDE TO RESIST THAT PRESSURE. This may occur in two ways: first, and most frequently with locomotives, from insufficient strength of the boiler to bear the ordinary working pressure; and second, from the gradual increase of heat and pressure until the latter is greater than the boiler was calculated to bear.

Insufficient strength may be due: 1, to defects of the original design, owing to the ignorance of the strains to which the material of the boiler will be exposed, and its power of resistance: 2, to defective workmanship and material, which can usually be discovered by careful inspection; 3, to the reduction of the original strength of the boiler by ordinary wear and tear or neglect, which can also usually be discovered by careful inspection.

The first two causes have been fully discussed in the part relating to boiler construction, and the last under the head of inspection of locomotives.

Over-pressure is nearly always due to some defect of the safety-valve, or to the fact that it is overloaded. This latter often occurs when safety-valves are set by an incorrect steam gauge, which indicates too little pressure. Over-pressure may also occur by letting an engine stand alone with a large fire in its fire-box and possibly with the blower turned on.

A boiler may, by suddenly opening the throttle-valve, undoubtedly be subjected to very severe strain that may possibly be sufficient to cause its destruction, even though it had sufficient strength to bear the ordinary pressure at which the safety-valve blows off. Suddenly opening or closing the throttle-valve may produce a violent rush of steam and water against the part of the boiler whence the steam is drawn. The percussion of the water and steam in such cases has been known to shake the whole boiler, and to lift the safety-valve momentarily right off its seat.* The weakest parts of a locomotive are the two sides where the barrel joins the outside fire-box. Many boilers, especially those with a high wagon-top, have flat spaces at this point, which it is impossible to stay properly. It is at this point, too, that the expansion and contraction of the tubes and the outside shell exert their greatest strains, and it will therefore be found, generally, that the seams at this point begin to leak before any others, and for these reasons it is believed that all the seams which join the outside shell of the fire-box to the barrel should be double-riveted.

The practice of ascribing steam-boiler explosions to obscure causes has been productive of much mischief, as it engenders a carelessness on the part of those having charge of them, who have been led to believe that no amount of care will avail against the mysterious agents at work within the boiler. Explosions are also, in the absence of other convenient reasons, very generally attributed to shortness of water. This is often nothing more than a convenient method of shifting the responsibility from the builder or owner of the locomotive to the runner or fireman, who, if not killed by the explosion, in many cases might just as well be, so far as his ability to defend himself is concerned.†

QUESTION 828. *What should a locomotive runner and fireman do to avoid and prevent explosions?*

Answer. 1. The height of the water in the boiler should always be maintained so as to cover the heating surfaces. 2. The boiler should be kept as clean—that is, as free from scale, mud, and other impurities, as possible. 3. It should never be subjected to strains from sudden heating or cooling. 4. The steam-gauge and safety-valves should be examined and tested frequently, to be sure they are in order; and, 5, they should examine every part of the boiler which is accessible, but especially the stay-bolts, to see that there is no fracture of any part or any injurious corrosion or other dangerous defect.

QUESTION 829. *If from any defect of the safety-valve or other cause the steam should rise beyond the limit of pressure that should be carried, what should an engineer do?*

Answer. He should open the furnace door and heater cocks, and let the steam blow into the tank, start the injector, and if the case is critical blow the whistle, which will allow some of the steam to escape.

QUESTION 830. *What should be done in case of the bursting or collapse of a tube?*

Answer. As soon as possible after it occurs, the runner must stop the train and reduce the steam pressure. The water escaping from the flue will usually quench the fire. When the steam pressure is reduced the engineer should close, first, the end of the flue in the fire-box, and then that in the smoke-box, by driving in *iron plugs*, which are usually provided for the purpose. These plugs are attached to the end of a bar, with which they are inserted into the tubes. If the escape of water and steam from the tube is so great as to make it difficult to see the end of the tube, the steam may sometimes be drawn up the

* This expression means, among railroad men, to signal to brakemen by blowing the whistle to apply the brakes.

† See Fifth Annual Report of the American Master Mechanics' Association, page 196.

* Wilson on Boiler Construction.

† *Ibid.*

chimney by starting the blower. If, however, the escape is so great as to make it impossible to insert the plug, then the steam pressure must be reduced by running with both pumps on, or by starting the injector; or it may be necessary to smother or draw the fire and cool off the engine. When a flue collapses, the front end of which is behind the steam or petticoat pipes, it is usually necessary to cool off the engine before a plug can be inserted, especially if any considerable amount of water and steam escape from it. While driving in the plug, the engineer and fireman should always keep themselves in such positions that the plug cannot hit them in case it is blown out by the steam. If the engine is not supplied with iron flue-plugs, a wooden plug can be cut of the proper size and driven in. This can be attached to the bar referred to and inserted; but if no such bar is carried with the engine, the wooden plug can be made on the end of a long pole and then cut nearly off. It is then inserted into the flue and driven in and broken off. It will be found that such plugs will burn off even with the end of the flue, but will not burn entirely out.

QUESTION 831. *What should be done in case a bolt, stud, rivet, or cock blows out of the boiler and thus allows the steam or hot water to escape?*

Answer. If it is accessible, cut a plug on the end of a long pole and drive it into the hole in the same way as described above. This will avoid the necessity of cooling off the engine; but in some cases it will be found that a plug cannot be inserted or driven in without drawing the fire and cooling off the boiler.

QUESTION 832. *In case it is found necessary to draw the fire and cool off the boiler, and if so much water has escaped as to uncover the crown plate, what must be done?*

Answer. If the leak has been stopped or the fault remedied, one of the safety-valves should be taken off and water poured into the boiler with pails or buckets through the opening left by the removal of the safety-valve until the crown sheet is covered. The fire may then be kindled again and the engine complete its journey. When bituminous coal is used for fuel, the necessity for drawing the fire in case of accident may often be avoided by completely covering or "banking" the fire with fine coal which has been wet, and closing the dampers and opening the furnace door. In this way the fire may be smothered and the boiler cooled without putting the fire out, so that after the defect is remedied it will not be necessary to rekindle it.

QUESTION 833. *What must be done in case of the failure of one or both the injectors, feed-pumps, or check-valves?*

Answer. If one of the injectors or pumps fails the other one may be used, but the defect or obstruction to the first should be remedied as soon as possible, because the second may also fail. A description of the most common defects of injectors will be found in answer to questions 785 and 786.

QUESTION 834. *In case a pump fails, how should it be examined in order to discover the defect?*

Answer. It should first be seen whether there is plenty of water in the tank, and whether the strainer is obstructed or not. The working of a pump is usually indicated by the stream which escapes from the pet-cock. If, when this is opened, steam and water escape, it is an indication that the check-valve is not working properly. If it is not working well hot water will escape if the pet-cock is opened when the engine is standing still, but the pump may still feed the boiler if the upper or pressure-valve works properly. When the check-valve does not work as it should, it is also indicated by the heating of the feed-pipe, owing to the escape of hot water from the boiler through the check-valve when the pet-cock is opened. If, when the plunger is drawn out of the pump, air is sucked in through the open pet-cock, then the upper or pressure-valve of the pump does not work, but the working of the pump may still be secured by the working of the check-valve; but if the pump, air-chamber, and feed-pipe then get filled with air, the plunger may compress this air at each stroke, and as it can then follow the plunger during its outward stroke, the latter will not suck water, but will simply compress the air during the inward stroke, which will then expand during the outward stroke. This will be indicated by the escape of air from the pet-cock when the plunger is moving inward, and the suction of air when the plunger is moving outward. This can be known by holding the hand in front of the pet-cock. Usually, however, the air is mixed with water, so that the stream which escapes from the pet-cock is broken or irregular. If air escapes from the pet-cock during the inward stroke of the plunger, but none is sucked in during the outward stroke, it shows that there is a leak somewhere in the pump or pipes, and that it is pumping air instead of water. The leak may be in the stuffing-box of the plunger, the joints of the pump or pipes, in the hose or their connections with the supply-pipe or tender. If neither air nor water escapes from the pet-cock during the inward stroke of the pump plunger, or if the stream of water at that time is weak, then it indicates that the suction or lower valve of the pump is not working properly. The same thing will occur if the pipe, pump, or tender-valve is obstructed. If there is a cock, as there always should be, just above the suction-valve, it will aid us very much to discover the fault when the pump will not work. If, when this cock is opened, cold water escapes from it, the fault is in the suction-valve; if hot water, then it is the pressure and check-valves which are leaky, obstructed, or broken, and consequently the hot water from the boiler leaks back into the pump. In the absence of such a cock, the fault can often be discovered by feeling the pump barrel with the hand. If the pump cannot be made to work, and the fault is found to be in the lower valve, it must be taken out and examined; or if the fault is in the pipes, it can usually be easily remedied. If the pipes are burst with only a small fracture, it can usually be repaired temporarily by covering the aperture with canvas or rubber and wrapping twine around it tightly. The upper valve of a pump must, however, never be taken down without first being sure that the check-valve is tight, because if it is not, the person will be likely to be scalded in taking the pump apart.

Only after all the appliances for feeding the boiler have failed and the water is so low as to be in danger of exposing the crown-sheet, should the fire be drawn or banked, and the runner should then at once give the proper signals for warning and the protection of his train, and if he is unable to repair the pumps or injector, he must send for aid to the nearest accessible point.

Directions for taking care of pumps in cold weather have already been given in the answers to Question 242.

QUESTION 835. *What are the principal causes of broken cylinders and cylinder-heads?*

Answer. Such accidents are usually caused by collisions, water in the cylinder, broken cross-heads, piston-rods, main connecting-rods, crank-pins, or pistons.

QUESTION 836. *What is often the origin of such accidents?*

Answer. They are often due to neglect in opening the cylinder-cocks, taking up lost motion in boxes, keys, or bolts. Lost motion of the brass bearings of the main connecting-rod, or a loose key in the piston-rod, or loose bolt in the follower-plate cause an undue strain on the connected parts which eventually results in a breakage. The same thing occurs when such parts as the pistons, piston-rods, guides, or pump-plunger are out of line.

QUESTION 837. *What should be done in case of the breaking or bursting of a cylinder or cylinder-head?*

Answer. If the guides, cross-head, main connecting-rod and crank-pin are uninjured they need not be removed, but the piston-rod may be disconnected from the cross-head, and the piston should be taken out of the cylinder. If any of the above parts are injured so that they will not work, then the main connecting-rod must be taken down on that side of the engine. In doing this care should be taken to put back, in their proper places, all liners—if there are any—in the straps. This will save some trouble in replacing the rods. The piston should then be moved to the front or back end of the cylinder and wooden blocks be placed between the guides so as to fill up the space between the cross-head and the end of the guide-bars, and thus prevent the cross-head and piston from moving. If a single guide is used blocks can be put above and below the cross-head, and bolted or tied with rope in their places. It is usually best to block the piston at the extreme back end of the cylinder, because in that position, if it should get loose and be driven to the front end, less damage would be done than would follow if the piston was at the front end and was driven backward so as to injure the back-head, guides, etc. On some engines, such as moguls and consolidations, the piston must be placed in the front end of the cylinder when the cross-head is blocked, because the crank-pin of the front driving-wheel will not clear the cross-head if the latter is at the back end of the guides. When the cross-head is blocked the valve stem should be disconnected from the rocker, and the valve moved to the middle of the valve face, so as to cover up both steam-ports and prevent steam from entering the cylinders and moving the piston. It can be known whether the valve is in the middle of the valve face by admitting a little steam to the steam-chest and opening the cylinder-cocks. If it is not in the middle of the face, so as to cover both ports, steam will escape at the end of the cylinder whose port is uncovered. When the valve is in the middle of the face no steam—excepting that due to the leakage of the valve—will escape at either end. It must then be fastened in that position by screwing up *one* of the bolts of the stuffing-box of the valve stem, so as to make the gland bind against the valve stem. When metallic packing is used the valve stem must be wedged or tied in its place.

If both front cylinder-heads are broken and the working parts of the engine are uninjured the steam-chest cover should be taken off, and the front steam-ports filled with wood. The engine can then be run with a light train, by admitting steam into the front ends only of the cylinders.

If one or both of the cylinders are disabled the train should be run cautiously to the next station. If the engine is not able to haul the train, then it should be uncoupled and run to the first telegraph station or other point where the aid of a helping engine can be obtained or telegraphed for. In the mean while, the train must be protected by the proper signals. Should the engine continue its journey, it must be started, if it should happen to be standing at the dead-point, by *pushing* or by means of *crow-bars*. In so doing, however, the bars should not be put between the spokes of the wheels, as they may easily be caught in the wheels when the engine starts, and in this way the spokes be broken or the persons who are using the crow-bars be badly hurt. If it is necessary to disconnect the engine, in freezing weather, then all pipes, pumps, and injectors liable to freeze must be drained. If there are no cocks or plugs for this purpose, then the connections should be slacked up so as to allow the water to run out, and when it is possible to do so blow steam through the pipes to clear them of water.

QUESTION 838. *In case an engine must be towed, what must always be done?*

Answer. The main rods and the valve stems must always be disconnected, for the reason that it is impossible, or very difficult, to keep the pistons and valves properly lubricated without steam on the engine, and, therefore, if they were in motion when the engine was running without steam, they are liable to cut the cylinder and valve-seats. If there is danger of the water in the boiler and in the tank freezing they should both be emptied.

QUESTION 839. *What must be done in case a steam-chest or steam-pipe is broken?*

Answer. The main rod and valve stem on that side must be disconnected, as already explained. If a steam-chest is broken a block of wood should be bolted over the mouth of the steam passage, so as to prevent the escape of the steam from the steam-pipe on that side. It will sometimes require considerable ingenuity to devise means of fastening such a block or blocks of wood so as to cover the mouth of the steam passage. As cylinders are now usually made, the blocks can be fastened by cutting them to the proper form and size, and then placing a thick block on top, and bolting the steam-chest cover down on top of it. If the cover is broken, a part of it may be used or a piece of plank with a few holes bored into it, or fish-plates may be employed instead. In some cases a piece of board can be bolted over the end of the steam-pipe. When the latter is broken, it should be taken down and a piece of board or plank bolted over the opening of the T-pipe to which the steam-pipe was attached. Usually it is difficult to take down a steam-pipe in the smoke-box, for the reason that the bolts and nuts are rusted fast and cannot be unscrewed.

QUESTION 840. *What must be done if a piston, cross-head, connecting-rod, or crank-pin is broken or bent?*

Answer. If the piston, cross-head, or main connecting-rod or main crank pin is broken, the same course must be pursued as when a cylinder is broken. If a coupling-rod or a crank-pin of a trailing-wheel of an engine with four coupled wheels is broken, then it is necessary to take down both the coupling-rods, but not to disconnect the main connecting-rods or their attachments, unless they are injured. On engines with six or eight wheels coupled, if any excepting the main crank-pins are broken, then the only coupling-rods which must be taken down are those connected to the pair of wheels on which the crank-pin is broken.

QUESTION 841. *If one of the coupling-rods connected to a pair of wheels is taken down, why must the other one be taken down also?*

Answer. Because if only one rod is used on a pair of wheels there is then nothing to help the cranks of those wheels past the dead-points, so that in starting, or if they are moving slowly when they reach these points, they are quite as likely to revolve in one direction as the other. If they happen to turn in the reverse direction to that in which the wheels to which they are coupled are moving, then the crank-pins of one or the other pair of wheels are very liable to be broken or bent.

QUESTION 842. *What must be done if a driving-wheel or tire breaks?*

Answer. If a tire on a main driving-wheel or the wheel itself breaks, the driving-box of the broken wheel or tire should be held up clear of the rails by putting a wooden block under the box. If the crank-pin, connecting-rods, etc., have not been injured it is not essential to take the coupling-rods down. If, however, it is necessary to disconnect the main rods on both sides, then, of course, all the coupling-rods must be taken down. If both of the main driving-wheels have been disabled, then both of them must be blocked up. It is possible, but not probable, that both tires and even part of both wheels might be broken, leaving the crank-pins and connecting-rods intact. In that event by blocking up the boxes it would not be essential to disconnect any of the rods. Usually, however, when both of the main driving-wheels are broken both sides must be disconnected and the engine be towed in.

If a trailing or leading driving-wheel or tire is broken the wheel should be blocked up and the coupling-rods connected to the pair of disabled wheels must be taken down. When both trailing wheels or axles are broken the engine can sometimes be run to a side track by supporting part of the back end of the engine on the tender. This can be done sometimes by chains and pieces of rails or timber, attached either to the engine or tender frame. An ordinary American engine can then be run on three driving-wheels, but it must be run with the utmost caution. If the engine has more than four driving-wheels there is usually less difficulty in running it, if one of the main wheels is injured, than if there are only four.

QUESTION 843. *What should be done in case the flange of a tire or wheel is broken?*

Answer. All that can be done is to run very cautiously and slowly, especially over frogs and switches.

QUESTION 844. *What should be done in case a driving-axle breaks?*

Answer. If a main driving-axle breaks outside of one of the boxes, the wheel next to the break should be removed, the box blocked up, and the engine be disconnected on that side and all the coupling-rods on the other side be taken down. The engine can then be run without the train to the nearest telegraph station. If the main axle is broken between the boxes, all that can be done is to disconnect both sides, block up the wheels of the broken axle, and send for assistance.

If a leading or trailing axle breaks the coupling-rods connected thereto must be taken down. If the break is outside the boxes, the loose wheel must be removed, and its box blocked up. If the break is between the boxes, both wheels must be blocked up and the engine run without the train, as described for broken wheels or tires.

It is almost impossible to give directions which will be applicable to all the accidents of this kind that may occur to different kinds of engines. In such cases, if assistance or a telegraph office is near where the accident occurs, it is usually best to send for help at once, rather than take the risks which attend the attempt to run an engine so seriously injured.

QUESTION 845. *What must be done if an engine-truck wheel or axle breaks?*

Answer. It is usually best to chain up the end of the truck-frame over the broken axle or wheel to the engine frame and place a cross-tie across the other end of the truck-frame, between it and the engine frame, so that the weight of the engine may rest on the cross-tie. If a part of the flange or a piece of the wheel is broken out, the wheels should be turned around so that the unbroken part will rest on the rail, and they should then be chained or otherwise fastened so that they cannot revolve, and thus be made to slide on the rails and carry the weight of the engine in that way. The same plan is employed if a tender wheel breaks, but one end of a tender-truck frame must be chained up. It is usually necessary to place a cross-tie across the top of the tender, and fasten the chains to it.

QUESTION 846. *What must be done in case a driving-spring, spring-hanger or equalizing-lever breaks?*

Answer. As the breaking of a spring or spring-hanger may cause a more serious accident, the engine and train should be stopped as soon as possible after it occurs. If the hanger is broken and there is a duplicate on hand, it should be substituted in place of the broken one. If there is no duplicate, then the spring should be taken down, and a wooden block be placed between the top of the driving-box and the frame to support the weight which before rested on the spring. In order to insert this block, if it is a front spring which is broken, it is usually best to raise the engine with jack-screws or run the back wheels on inclined blocks of wood placed under each of the back wheels. This raises the weight off from the front wheels, and the block can then be inserted betwen the box and frame. If it is one of the springs over the back wheels which is broken, the front wheels should be run on the wooden wedges. Such wedges can soon be cut out of a cross-tie with an axe, or by sawing a square stick of wood diagonally it will make two such wedges. The end of the equalizing lever next to the broken spring must be supported by inserting a piece of wood under it. This will usually be held securely by the weight which is suspended from the opposite end, bearing the blocked end down on the block.

In case a hanger breaks a chain may be used as a temporary substitute.

QUESTION 847. *What should be done if an engine-truck or tender spring breaks?*

Answer. Very much the same course must be pursued that is employed when a driving-spring breaks, excepting that usually the weight can be lifted off from a truck-box easier by placing a jack under the end of the truck-frame than by the

method described. Usually, too, each of the truck-springs supports the weight on two of the wheels, so that the two boxes must be blocked up.

QUESTION 848. *If a truck wheel or axle breaks or an axle is bent, what should be done?*

Answer. If a back wheel of a truck is broken it can be chained up, clear of the track, to a cross-tie on top of the engine frame or on top of the tank, or it can be fastened so that it cannot revolve and be allowed to slide on the rails. If a front wheel or axle of a four-wheeled truck is broken or bent, the engine may be jacked up and the truck turned around so as to bring the sound pair in front.

QUESTION 849. *What must be done in case the engine-frame is broken?*

Answer. Usually very little need be done excepting to exercise more than usual caution in running, and to reduce the speed. Of course the breakage of a frame may disable the engine, but ordinarily in such accidents that is not the case.

QUESTION 850. *How can it be known if an eccentric has slipped on the axle?*

Answer. It is indicated at once by the irregular sound of the exhaust, or, as locomotive runners say, the engine will be "*lame.*"

QUESTION 851. *When it is known that an eccentric has slipped, how can it be learned which is the one that is misplaced?*

Answer. This can usually be learned by examining the marks which should always be made on the eccentrics and on the axles. If no such marks have been made by the builder of the engine, the engineer himself should make them, after the valves have been set correctly. The effect upon the valve when an eccentric slips is either to increase or diminish the lead. Therefore, by running the engine slowly with the link first in full forward and then in full back gear, and observing whether steam is admitted at each end of the cylinder just before the crank reaches the dead points, it can be known which eccentric has moved. If it has slipped in one direction the lead will be increased and steam will be admitted to the cylinder some time before the piston reaches the end of the stroke. If it has moved the opposite way, the lead will be diminished and steam will not be admitted until after the piston has reached the end of its stroke. The admission of steam will be indicated by its escape from the cylinder-cocks.

QUESTION 852. *If by any means the valve stem or either of the eccentric rods should be lengthened or shortened, how can it be known?*

Answer. The crank on one side should be placed at one of the dead points and the cylinder-cocks opened; then admit a little steam to the cylinder, by opening the throttle-valve slightly, and throw the reverse lever from full gear forward to full gear backward, and observe whether steam escapes all the time from the end of the cylinder at which the piston stands. Then repeat the operation with the crank at the other dead point. If either of the eccentric rods or the valve stem have been lengthened or shortened, it will cause the valve to cover the steam-port either at the front or back end of the cylinder, so that no steam will escape from the cock at that end. If the length of one of he eccentric rods has been changed, then when the altered rod is in gear the valve will have too little or no lead at one end of the cylinder and too much at the other. If, therefore, this occurs when the forward rod is in gear and *not* in back gear, it indicates that the length of the forward rod has been altered. If the reverse occurs it shows that it is the back-motion rod whose length has been changed. It must be observed that if the length of an eccentric rod is altered the lead will be changed only at that part of the link which is operated by the altered rod. That is, if the forward eccentric rod is too long or too short, the lead at the front and back ends of the cylinder in forward gear only will be affected. If the back eccentric rod is changed the valve will be affected only in back gear. If, however, the length of the valve stem is changed, the lead will be changed in both forward and back gear. The valves on each side of the engine can, of course, be tested in the same way.

QUESTION 853. *When it is discovered which eccentric has slipped, how should it be reset?*

Answer. If it has been marked, it is simply turned back so that the marks correspond with each other again. This is done by first loosening the set-screws, and, after the eccentric is turned to the proper place, tightening them up again. When an eccentric slips it is often caused by the cutting of the eccentric-straps, valve or other part of the valve-gear, so that these should always be examined to see whether they are properly oiled. If the eccentrics have not been marked, the valve may be set by placing the crank at the forward dead-point, and the reverse lever in the front notch of the sector and the full part of the forward-motion eccentric *above* the axle. Then admit a little steam into the steam-chest, open the cylinder-cocks, and move the forward-motion eccentric slowly forward until steam escapes from the front cylinder-cock, which will show that the steam-port is opened and the valve has some lead. To set the backward-motion eccentric the crank is placed in the same position, but the reverse lever is thrown into the back notch and the full part of the eccentric is placed *below* the axle. Then move this eccentric forward until steam escapes from the *front* cylinder-cock as before. In order to verify the position of the eccentrics the crank may be placed at the back dead-point and the reverse lever moved backward and forward, at the same time observing whether steam escapes from the back cylinder-cock when the link is in both back and forward gear.

QUESTION 854. *What should be done in case an eccentric-strap or rod, or rocker arm rocker shaft, or the valve-stem breaks?*

Answer. If an eccentric-strap or rod breaks, the broken rod and strap should be taken down, and the valve-stem disconnected from the rocker and the valve fastened in the middle position of the valve face, and the engine should be disconnected on one side and be run with one cylinder only. The same course must usually be pursued if a rocker breaks. If the valve-stem breaks, it is not necessary to disconnect the link and eccentric rods, but simply to fasten the valve in the center of the valve face.

QUESTION 855. *If a link hanger or saddle, or a lifting arm should break, what may be done?*

Answer. The valve-gear may be used on that side of the engine by putting a wooden block in the link slot above the link block, so as to support the link near the position at which it works the valve full stroke forward. Of course the engine can then be run in only one direction, and should therefore be run with the utmost caution. If, however, it should be necessary to back the train on a side track, it can be done by taking out the wooden block and substituting a longer one, so that the link will be supported in a position near that at which it works the valve full stroke backward. These blocks must be fastened in some way, either with rope or twine, so that they will be held in their position when the engine is at work.

QUESTION 856. *If the lifting shaft itself or its vertical arm, the reverse lever or rod, should break, what can be done?*

Answer. If it is impossible to devise any temporary substitute or method of mending them, but both links can be blocked up as described above. The engineer should determine as near as he can the point of cut-off at which the engine must work to reach its destination. For forward motion long pieces of wood would be placed below the link-block and short ones above. To back the engine these pieces must be reversed. The same plan can be used if one or both of the lifting shaft-arms, the reversing rod, the link-hanger, or the hanger-pin breaks.

QUESTION 857. *If a valve, valve-yoke, or valve-stem is broken inside of the steam-chest, how can it be known and located?*

Answer. It will make itself known by the irregular exhaust of the steam. To ascertain on which side the defect, is one of the crank-pins should be placed at a dead-point, and the throttle-valve and cylinder-cocks opened. Then move the reverse-lever from full stroke forward to full stroke back. In doing this, if the valve gear is in good condition, the valve will have lead alternately at the front and the back end, and steam will escape from the front and back cylinder-cocks as the reverse-lever is moved. If the valve-stem or yoke is broken the valve will not be moved as it should be by the reverse-lever, and if the valve is broken, probably it will be indicated by the irregular or constant escape of steam. By trying both sides of the engine the defect can thus be located.

QUESTION 858. *If the valve, valve-stem, or yoke is broken, what must be done?*

Answer. If the valve-stem is broken outside of the steam-chest the valve must be moved to cover both parts and then fastened in that position and the engine disconnected on that side, as already described. If the break is inside, the steam-chest cover must be taken off and the valve secured, with blocking or otherwise, so as to cover the ports, and the opening for the valve-stem must be closed with a wooden plug inserted from the inside of the chest, so that the steam pressure will not blow it out.

If the valve is broken a wooden board 1 in. thick should be placed over the valve face and blocks placed on top of it, so that when the steam-chest cover is screwed down it will hold the board on to the valve face.

QUESTION 859. *If the valve face is broken, what should be done?*

Answer. If the metal of the face is broken, so that the front port cannot be closed, then the piston should be fastened at the back end of the cylinder and the valve should be secured, so as to cover the exhaust and the back steam-ports, that side of the engine being disconnected. If the back steam-port is the one injured, then the piston and valve should be placed in the reverse position. If either of the bridges between the ports are broken, then the valve should cover all of them.

QUESTION 860. *In case the throttle-valve should fail, what should be done?*

Answer. If such an accident occurs, especially if it happens about a station, it is attended with great danger. If it is found that steam cannot be shut off from the cylinders with the throttle-valve, all the brakes should be applied and the reverse-lever should be placed in the middle of the sector. If this does not prevent the engine from moving, the reverse lever should be alternately thrown into forward and then into back gear, and at the same time every aperture, such as the safety-valve and heater-cocks, should be opened, and every means be taken to cool the boiler as quickly as possible. The fireman should open the furnace door, close the ash-pan dampers, and start the blower so as to draw a strong current of cold air into the furnace and through the tubes. At the same time the injector should be started and the fire drawn as quickly as possible. After the boiler is cooled, the cover of the steam-dome may be removed and the valve examined if the defect cannot be discovered in any other way. Of course if the accident occurs on the open road, the train must be at once protected by sending out signals in each direction.

QUESTION 861. *What must be done in case a coupling breaks?*

Answer. When a coupling between the cars or tender breaks, if the front end of the train is immediately stopped, there will be danger that the back end of it, which is broken loose, will run into the front end, and thus do great damage. As it always occurs, when a coupling of a passenger train breaks, that the signal bell in the cab is rung, the first impulse of a runner under such circumstances is to stop the engine. He should, however, be careful not to do so if on shutting off steam he finds that the train has broken in two, but should at once open the throttle in order to get the front end of the train out of the way of the rear end. The ease with which the speed of a train is arrested with continuous brakes has increased the danger of accident from this cause. Usually a runner learns by the sudden start of the engine that the train has separated, and when that occurs he should never apply the brakes.

QUESTION 862. *If from any cause the supply of water in the tender becomes exhausted, what must be done?*

Answer. It is best, if it can be done without risk of injury to the engine, to run the train on a side track and then draw the fire. If no water can be obtained near enough to supply the tender with buckets, help must be sent for; but if there is a well, stream, or pond of water near, the tender can be partly filled by carrying water.

QUESTION 863. *In case an engine becomes blockaded in a snow-storm with plenty of fuel, but runs out of water, what can be done?*

Answer. Snow should be shoveled into the tender and steam admitted through the heater cocks so as to melt the snow.

QUESTION 864. *If a locomotive without an injector should be obstructed in a snow-storm or in any other way so that it could not move, and therefore could not work the pumps, what should be done in case the water in the boiler should get low?*

Answer. The weight of the engine should be lifted off from the main driving-wheels and the coupling-rods disconnected from the main crank-pin, so that the main wheels can turn without moving the engine. These can then be run and the pumps thus be worked. The weight can usually be most conveniently taken off from the main wheels by running the trailing wheels on wooden blocks, and thus raising up the back end of the engine.

QUESTION 865. *If it is impossible, in a snow-storm or in very cold weather, to keep steam in the boiler without danger, what should be done?*

Answer. Draw the fire, blow all the water out of the boiler, empty the tanks, disconnect the hose, and slacken up the joints in the pumps and injector so that all the water in them can escape, and thus prevent them from freezing up.

(TO BE CONTINUED.)

Manufactures.

"Machined" Car Wheels.

THAT ordinary chilled cast-iron wheels are not true, and are not of uniform size, every master car-builder and every other person who has given attention to the subject knows only too well. The causes are numerous. In the first place the chill-molds in which the wheels are cast are not made of uniform size. One maker turns molds which are nominally of a given size, several eighths of an inch larger or smaller than his competitor does. Next, after an ordinary chill-mold has been in use for a longer or shorter time, it is liable to change its shape, by reason of the frequent and great changes of temperature to which it is subjected when in use—that is, after being used for a time, its interior surface, which forms the tread of the wheel, instead of being a true cylinder or a true frustrum of a cone, changes its shape more or less. There are abundant illustrations of this action of heat on castings. For example, a large slide-valve, if ground perfectly tight when it is new, is very liable to leak after it has been in use a short time and exposed to the heat of the steam. The same thing is true of the double puppet throttle-valves used on locomotives.

If, after being in service a short time, they are then reground, they are apt to stay tight. Malleable castings are nearly always more or less distorted in the annealing process. A ⅛ in. hardened steel cylindrical gauge and ring, belonging to the writer, which originally fit each other perfectly, after being exposed to the ordinary changes of temperature of the atmosphere, were found to have changed their form, and the plug was sufficiently loose in the ring, so that its "shake" could be felt perceptibly. It is believed that if the chill-molds of car-wheels were thoroughly annealed before they are turned, they would be much less susceptible to a change of form on account of the variations in temperature to which they are subjected.

This lack of mechanical veracity in chilled car-wheels has long been recognized, and, like many other forms of mendacity, has been deplored by those who are best acquainted with the evils that it entails.

The proprietors of the New York Car Wheel Works of Buffalo, N. Y., recognizing the impossibility of casting perfectly true wheels, turned their attention, recently, to methods of trueing them up after they are cast, at a cost which would not be a serious obstacle in the way of using such wheels. After some years of experiment they perfected a satisfactory machine for doing this work, and besides making the wheels, they are now prepared to supply them with their treads machined, so that their peripheries are true circles. The wheels are first bored, and are then placed on a self-centering mandrel, and the outer part or tread of the wheel is ground true. There is nothing novel in this excepting that this Company has erected a plant specially designed for this kind of work, and for doing it at a very low cost and in the best manner. They say that a variation of one sixteenth in boring a wheel doubles the cost of machining its tread. Their aim is to cast the wheels and bore them as true as possible. This reduces the cost of machining which with special machines can then be done very rapidly.

Marine Engineering.

THE *Columbia*, the latest addition to the Hamburg-American Line, made her first passage from Southampton to New York in 6 days and 23 hours, averaging 447 miles a day. The *Columbia*, which was built by the Laird Brothers, Birkenhead, England, is 470 ft. long, 56 ft. beam, 38½ ft. deep, and draws 24 ft. loaded, her displacement being about 10,000 tons. She is built of mild steel with double bottom, and is divided into 12 water-tight compartments. She has twin screws, each with an independent set of triple-expansion engines. The cylinders are 40 in., 66 in., and 101 in. in diameter, and 66-in. stroke. The propellers are 18 ft. diameter and 32 ft. pitch. Steam is furnished by six boilers 17 ft. 3 in. long, and 15 ft. 4 in. in diameter, and three boilers of the same length but 14 ft. 3 in. in diameter. The working pressure is 150 lbs., and the two engines have developed 13,500 H.P. together.

A BARGE on a new plan has been recently launched at Duluth; it is 260 ft. long, 36 ft. beam, and 22 ft. deep, and has a carrying capacity of 3,000 tons. It is built of steel with double bottom, is divided into water-tight compartments so arranged that one or more of them can be filled when the vessel is only partly loaded. The upper part of the barge has a sort of turtle-back deck, in order to offer the least resistance of the wind and avoid the danger of breaking loose from the tug during storms. It is intended to carry iron ore.

THE new steamship *Kansas City*, built by the Delaware River Iron Shipbuilding Company for the Ocean Steamship Company (New York-Savannah Line), was launched at Chester, August 10. The *Kansas City* will have a capacity of 6,500 bales of cotton and accommodations for 240 passengers; she is 346 ft. long, 45 ft. beam, and 27½ ft. depth of hold. She is built of steel throughout. The engines are triple-expansion, with diameter of cylinders respectively 33 in., 54 in., 86 in., by 54 in. stroke of piston. Eight return tubular boilers 12 ft. diameter by 11 ft. 6 in. long, each having two corrugated furnaces 48 in. in diameter, will supply the steam at a pressure of 160 lbs.

The propeller wheel is of the Hirsch pattern, with a mean pitch of 22 ft. 6 in. She is the tenth steamer built in the Roach yards for the Ocean Steamship Company.

A New Pneumatic Gun.

THE accompanying drawings show a new pneumatic piston gun for throwing shells loaded with high explosives. Fig. 1 is a section of the gun itself, and fig. 2 shows the method of compressing the air.

In fig. 1, which is a longitudinal cross-section of the gun, *A* is the air-compressing chamber having the sliding piston *B*, in the rear of which the explosive *C* (here represented as a blank cartridge) is inserted.

D is the barrel pivoted at *E* to the head-piece *F*, which closes the chamber *A*, and which is provided with the duct or passage *G* for the compressed air.

H is a lock for retaining barrel *D* in position after loading.

I is the mechanism, of well-known construction, for loading and firing the explosive, and *K* is a projectile.

The gun may be provided with trunnions, as shown.

The operation of the gun is as follows: Piston *B* having been pushed to the rear end of chamber *A*, as shown in the drawing, the explosive *C* and projectile *K* charged as shown, and barrel *D* locked in position, the explosive *C* is then discharged, driving piston *B* before it to the other extremity of the chamber *A*. The air compressed in front of piston *B* is conducted to the rear of the projectile in barrel *D*, where its expansion expels the projectile *C* from the barrel.

The head-piece *F* is shown in the drawing as screwed to the outside of chamber *A*; but it may also be screwed on the inside of the same, and the gun-barrel *D* may be made integral with the head-piece, in which case piston *B* would be pushed to its place and the projectile loaded from the muzzle of the gun without departing from the spirit of the invention, which consists, essentially, of an air-compression chamber adapted to contain

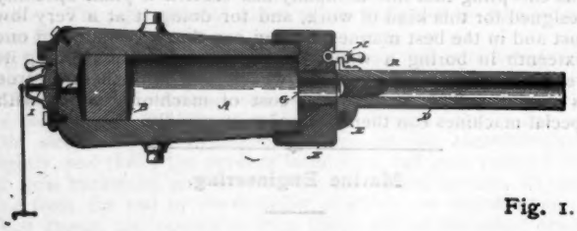


Fig. 1.

an explosive, a piston driven by the discharge of the explosive, a barrel or tube adapted to discharge a projectile, and means for communicating the air-compression produced by the piston to the projectile in the gun barrel or tube.

In fig. 2, which is a vertical cross-section of a mounted pneumatic gun, *A* is the air-compression chamber having a removable breech-piece *B*, of well-known construction, and provided with the firing mechanism *B'*.

C is the explosive.

D is a diaphragm of metal or other suitable material closing the end of the explosion-chamber and held in place by means of the cap *E E*, which screws onto and partly over the end of the air-compression chamber *A*. This diaphragm *D*, when thus secured in place, tightly closing the chamber *A*, acts as a pressure safety-valve, the resistance of the diaphragm providing one means for determining the degree of pressure that can be produced within the chamber.

F F is an air-tube open at both ends, which connects the compression-chamber *A* with the barrel *G* of the air-gun in the rear of the projectile *H*, as shown.

I is the breech-piece, removable for the purpose of inserting the projectile. *K K* are braces to hold the parts together.

The gun having been loaded, as shown in the drawing, with the projectile in barrel *G* forward of the entrance of the air-tube and the explosive in chamber *A*, the breech-pieces *B* and *I* are closed and diaphragm *D* firmly secured in place. On the explosion of the explosive *C* by means of the primer *B'*, or in any other well-known way, the contained air is at once greatly compressed, and this pressure, communicated through tube *F* to the rear of the projectile in barrel *G*, discharging the gun.

A gun of the following dimensions will give good results, illustrating the application of the process to a pneumatic gun, in which the diameter of the bore proper (barrel *G*) is 1¼ in.; length, 84 in.; diameter of air-tube (tube *F*) is 2 in.; length, 40 in.; diameter of air-compression chamber *A* is 3 in.; length, 38 in.; weight of projectile is two pounds; of powder-charge, eight ounces; and the resistance of plate *D* to blowing out, 45 lbs. per square inch.

Gas or gases of greater or less density as well as air may be used without departing from the spirit of this invention.

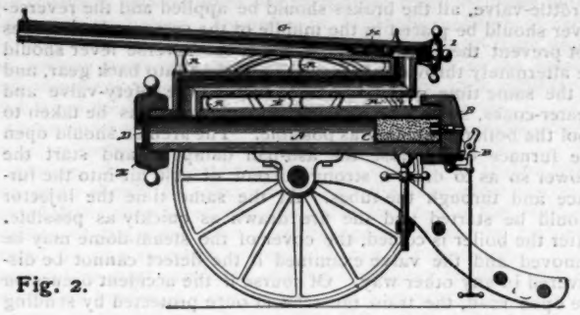


Fig. 2.

The essence of the invention consists in the production of an air-pressure by means of an explosive, which air-pressure may afterward be utilized in discharging a projectile.

This invention is covered by patents Nos. 407,474; 407,475, and 407,476, granted to Dana Dudley, and by him assigned to the Hotchkiss Ordnance Company.

Electrical Notes.

THE West End Railroad Company, which operates nearly all the street lines in Boston, has voted to increase its capital stock to $4,500,000, in order to introduce the electric system on its various lines. The system used will be the overhead wire, and this action is taken in consequence of experiments on its Arlington and Allston lines, and on the Cambridge and Brighton branches.

THE Safety Light & Power Company has commenced the erection of an extensive station in New York. This company will operate the Westinghouse alternating system, and the power for running the dynamos will be furnished by six Westinghouse compound engines, each of 150 H.P.

Cars.

THE Indianapolis Car Company is building 500 coal cars for the Missouri, Kansas & Texas Railroad.

THE new shops of the Minnesota Car Company at Duluth, Minn., are completed, and will soon be at work. They will have a capacity of 15 box cars a day.

THE Pennsylvania Railroad Company's recent large order for the building of freight cars has been distributed as follows: Altoona shops, 1,000 cars; Peninsular Car Company, Detroit, 500; Murray, Dougal & Company, Limited, Milton, Pa., 400; Pardee, Snyder & Company, Watsontown, Pa., 200; Erie Car Works, Erie, Pa., 300; Harrisburg Car Company, 200; Michael Schall, York, Pa., 100; Schall & Shoop, Dauphin, Pa., 100; Carlisle Manufacturing Company, Carlisle, Pa., 200 cars. Most of the cars are hopper gondolas.

MOST of the car works in Pennsylvania are busy with orders. The Lebanon Manufacturing Company has recently shipped 210 new 60,000-pound cars to the George's Creek & Cumberland Railroad, 250 coke cars to the Bell's Gap Railroad, and 100 coal cars to the Westmoreland Coal Company. The Jackson & Woodin Manufacturing Company, of Berwick, Pa., is building 50 hopper-bottom coal cars for the Delaware, Lackawanna & Western Railroad, and 400 cars for the New York, Susquehanna & Western Railroad. The Harrisburg Car Company has recently taken orders for 400 oil-tank cars for private shippers.

ORDERS for freight equipment recently placed by the Northern Pacific are among the heaviest of the year. The cars just ordered are of four classes, and aggregate 2,400, in addition to the orders placed earlier in the season for 500 furniture cars. Of these, the Peninsular Car Company, of Detroit, Mich., is building 400, and the La Fayette Car Company, of La Fayette, Ind., 100. The orders just placed are distributed as follows: Peninsular Car Company, Detroit, 370 box, 300 stock, 300 flat, and 300 gondola coal; Barney & Smith Manufacturing Company, Dayton, O., 430 box; United States Rolling Stock Company, 350 box; Wells & French Car Company, Chicago, 350 box.—*Northwestern Railroader.*

THE Centropolis Car Company, Centropolis, Kan., has just completed its works. The foundry has been running some time.

THE Dunham Manufacturing Company, Boston, has recently received orders for 2,000 of its freight-car doors.

SINCE the commencement of the year the Richmond & Danville has given out contracts for building 2,150 cars. A large number of these have been delivered, and it is expected to have them all delivered by October 1. The contracts were let as follows: To the Pullman Company, 420 box cars; to the South Baltimore Car Company, 560 box and 200 stock cars; to the Tredegar Company, 300 cars; to the United States Rolling Stock Company, 500 double-hopper coal cars, 100 coke, and 70 platform cars. All the box and stock cars will be equipped with air brakes and M. C. B. Standard couplers, and the open cars will be equipped with M. C. B. couplers. Four hundred of the box cars and all the open cars will be of 60,000-lbs. capacity. The balance of the cars will be 40,000-lbs. capacity.

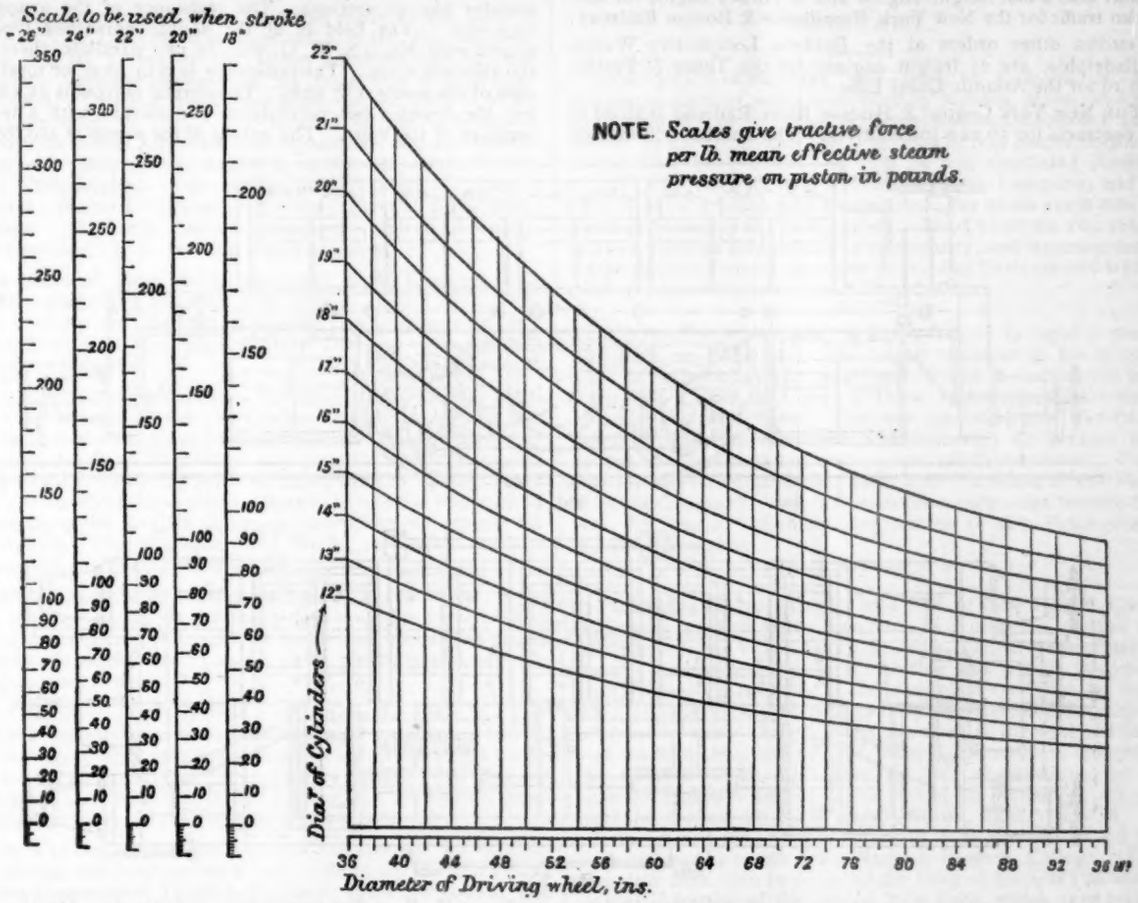
THE Litchfield (Ill.) Car Company is building 300 box cars for the Denver & Rio Grande and 200 refrigerator cars for the Cairo Short Line.

IT is reported that the Pennsylvania Railroad Company will try the Ford passenger car, the body of which is built entirely of steel.

Tractive Power of Locomotives.

(From the London *Engineer*.)

THE diagram herewith gives the tractive power, in pounds, of locomotives per pound mean effective steam pressure on piston, and is one which will be found very useful in solving all questions relating to size of cylinder for given tractive power, length of stroke, maximum diameter of driving-wheels, etc., and also for facilitating the comparison of the tractive power of different engines. As an example of the use of the diagram, suppose we require to know what will be the mean tractive power of an engine having cylinders 17 in. diameter by 22 in. stroke, and driving-wheels 60 in. diameter. At the point marked 60 in. on the scale of diameters of driving-wheels at the bottom of the diagram, with a pair of dividers measure the length of the ordinate from the base line up to the line marked 17 in. diameter, transfer this to the scale to be used when length of stroke equals 22 in., and read off 106 lbs. as the tractive force which will be exerted for every pound mean effective pressure on the piston, or $\frac{17^2 \times 22}{60} = 106$. Again, given the diameter of driving wheels, length of stroke, and tractive power, required the diameter of cylinders: Reduce the tractive power to pounds per pound of mean pressure, and taking this value on the scale to be used for the given length of stroke, set it off over the given diameter of wheels, and read off the diameter of cylinders required. Other uses of the diagram will readily suggest themselves to locomotive engineers.


Scale to be used when stroke
26" 24" 22" 20" 18"
350 300 250 200 150 100 90 80 70 60 50 40 30 20 10 0
22" 21" 20" 19" 18" 17" 16" 15" 14" 13" 12"
Dia' of Cylinders
36 40 44 48 52 56 60 64 68 72 76 80 84 88 92 96 in
Diameter of Driving wheel, ins.
NOTE. Scales give tractive force per lb. mean effective steam pressure on piston in pounds.

Manufacturing Notes.

THE Dunham Manufacturing Company, Boston, reports an order from the Rio Grande Western Railroad for Servis tie-plates to equip 40 miles of road; also large orders from the Missouri Pacific and the Northern Pacific.

THE Westinghouse Machine Company, Pittsburgh, report a large number of orders for their compound engines, ranging from 35 to 250 H.P. The works are running extra time to fill orders. In addition to the large sizes, a number of small compound engines are being sold, and the Company is making patterns for these engines down to as small as 3 H. P.

THE Pond Machine Tool Company, New York, has just received an order from the New York & New Haven Railroad for a steel tire turning lathe, for turning steel wheels on the axles; this machine weighs about 23 tons and permits the use of a broad-faced tool, taking the entire tread of both wheels at one cut. Several of these lathes are already in use on different roads. The Company is also building for the same road a 79-in. driving-wheel lathe with double quartering attachment.

THE modern plan of subdividing steam power—in other words, the primary transmission of power from the boiler to

the work by means of steam pipes in place of belts and shafting, is rapidly growing in favor. Westinghouse, Church, Kerr & Company are now fitting up the plant of the Long Island Railroad at East New York, using, in place of a single engine, three engines of 75, 60 and 25 H.P., respectively.

Locomotives.

THE Rhode Island Locomotive Works, in Providence, are building 12 consolidation locomotives for the Fitchburg Railroad and 2 eight-wheel engines for the East & West Alabama; also a fast freight engine and a Forney engine for suburban traffic for the New York, Providence & Boston Railroad.

AMONG other orders at the Baldwin Locomotive Works, Philadelphia, are 25 freight engines for the Texas & Pacific, and 19 for the Atlantic Coast Line.

THE New York Central & Hudson River Railroad is about to let contracts for 56 new locomotives. The number will include 50 freight engines, with six wheels coupled, and cylinders 19 × 26, weighing 60 tons each; five passenger engines for local service on the Harlem Division, ordinary American type, 17 × 24 in. cylinders, weighing 42½ tons each; and one dummy engine, for hauling freight on the New York City street tracks. —*National Car-Builder.*

THE Pittsburgh Locomotive Works are building several engines for the Richmond & Danville Railroad.

THE New York Locomotive Works, Rome, N. Y., are building 7 consolidation freight engines for the New York & New England Railroad.

An Electric Mine Locomotive.

THE accompanying illustration (from *Industries*) shows an electric locomotive built by Immisch & Company, London, England, for the Wharncliff-Silkstone coal mine. It runs on a line of 21-in. gauge, the mine tunnel being 4 ft. high by 4 ft. 6 in. wide, and its total weight is 2½ tons. Fig. 1 is an elevation and fig. 2 a plan of the engine.

The frame of the locomotive is supported on springs on axle boxes outside the wheels, and in order to secure a maximum degree of steadiness, four sets of storage cells have been suspended in front and rear of the wheels from the platform. The wheels are coupled by rods to fully utilize the weight for adhesion.

The storage battery consists of 44 modified Tatham cells, each box being 10 in. by 6½ in. by 11 in. high. The boxes are lead lined, and arranged in sections of three in wooden trays. Each box contains 19 plates, 7 in. by 4¼ in. by $\frac{7}{32}$ in. thick, and has a capacity of 150 ampère-hours, the weight being 53 lbs. The rate of discharge varies between 25 and 50 ampères, and at starting rises occasionally to 65 ampères. Taking 40 ampères as the average rate, the weight of these cells per H.-P. works out to nearly 500 lbs.; and per H.-P. hour storage capacity to 134 lbs. Messrs. Immisch & Company state that they are now engaged in working out several improvements, by which the storage capacity, as compared to weight, will be increased. The motor, which is placed underneath the platform and between the wheels, is of the ordinary Immisch type. The armature is 10 in. diam., and wound with No. 12 S. W. G. wire. There are 480 wires counted around the periphery, and the commutator has 48 sections. The resistance of the armature is 0.23 ohm. The field is of the double horseshoe type, and wound with No. 9 S. W. G. wire in two parallels, there being 560 effective turns. The resistance is 0.14 ohm, or total resistance of the motor 0.37 ohm. The normal current is 45 ampères, and the speed 1,000 revolutions per minute, with a terminal pressure of 100 volts. The weight of the motor is 450 lbs., and

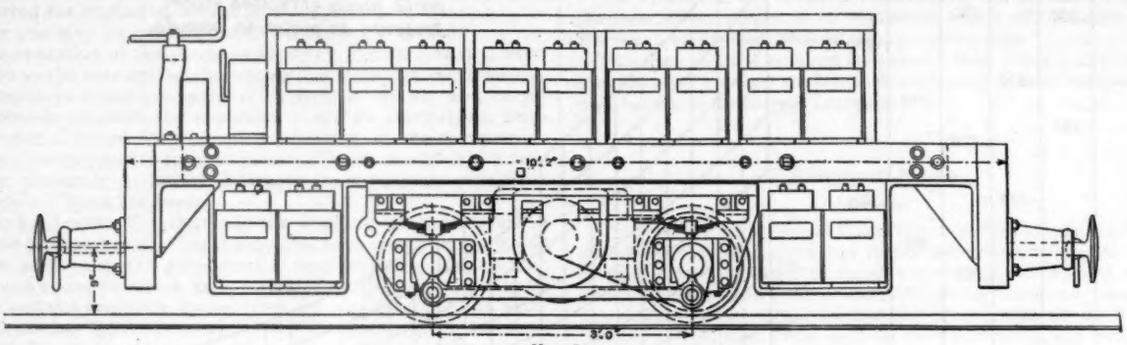


FIG. 1

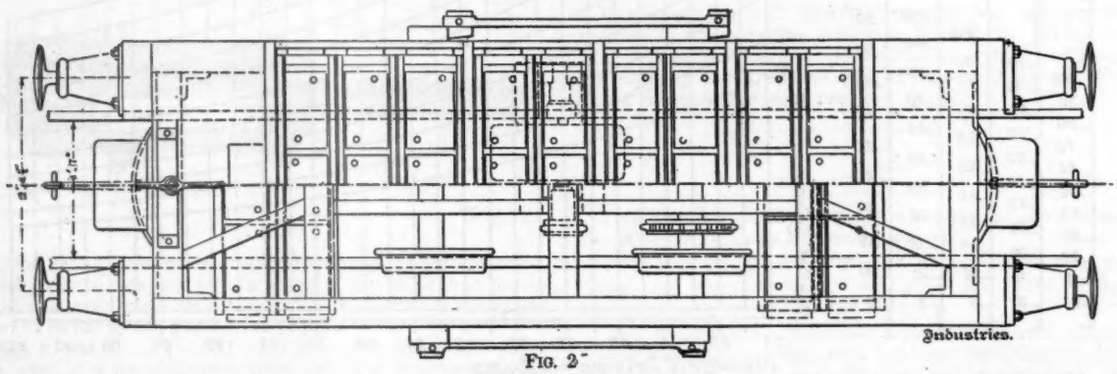


FIG. 2

it gives 4 H.-P. at 800 revolutions per minute. On the armature spindle is a small phosphor bronze pinion; this gears into four steel pinions, placed in the same plane, and 90° distant from each other. These pinions are bushed with gun metal, and run on steel pins carried on a cast-iron disk. The disk revolves on a journal turned outside of the end of the motor bearing. Outside of, but in the same plane as these pinions, is fixed an annular casting of gun metal, with teeth cut on the inside. The steel pinions gear into the ring, which forms a fulcrum on which they revolve when the motor spindle turns. The power is transmitted from the cast-iron disk by a sprocket pinion keyed to it on the inside next the motor, and a steel chain connects this sprocket pinion to a suitable wheel mounted on one of the axles, while the other axle is connected with this by the coupling rods already mentioned. The direction of motion is reversed by a switch, which reverses the magnetization of the field, and the speed is regulated by iron resistance coils. A brake is also provided. The current for charging the battery is furnished by an Immisch dynamo, which is driven by belt from a Willans engine.

Some trials of this engine were made on a surface line at the colliery, before it was put at its regular work in the tunnel. This line was 3,000 ft. long, having, in the order stated, 600 ft. level; 600 ft. grade 1 in 70 (75 ft. per mile); 450 ft. grade 1 in 40 (132 ft. per mile); 750 ft. grade 1 in 25 (211.2 ft. per mile, and 600 ft. grade 1 in 40). At the trial, on the grade of 1 in 70 the locomotive would just move a train of 20 loaded mine cars, weighing together 11 tons, and with 15 cars, representing 8¼ tons, a speed of three miles an hour was obtained, the current being 45 ampères at 100 volts pressure. On the grade of 1 in

40 the maximum load was eight cars, and on 1 in 25 it was six cars, the speed being a little over two miles an hour. On the level the locomotive could draw 30 cars, the current being 45 ampères.

Steel and Iron.

THE well-known firm of Hoopes & Townsend, Philadelphia, have purchased the entire plant of the Hare & Morgan Company, of Wilmington, Del., and will operate it under the name of the Hoopes & Townsend Company as an addition to the works in Philadelphia.

THE first cast of open-hearth steel was made at the Latrobe Steel Works, at Latrobe, Westmoreland County, Pa., on Wednesday, August 7, one of the 15-ton furnaces having been completed. Another furnace of the same size will be completed soon. This is a wholly new plant, the building of which was commenced in 1888. The product of the open-hearth plant will be rolled into tires for locomotive and car wheels. The branch office of the works is at No. 251 South Fourth Street, Philadelphia. The officers are: Marriott C. Smyth, President; Walter H. Bryant, Secretary; Ellwood W. Kimber, Treasurer; Guilliaem Aertsen, Manager; Julian Kennedy, Chief Engineer; J. K. Griffith, Superintendent.

THE National Tube Works Company, of McKeesport, Pa., have been awarded a contract for 80 miles of 12 and 16-in. pipe, to be used by the Northwestern Ohio Gas Company on their projected line from their Ohio field to Detroit. The contract amounts to $800,000.

THE Bookwalter Steel & Iron Company, 18 Cortlandt Street, New York, owners of the Bookwalter-Robert process for the manufacture of steel, have been advised that the exhibit of this process in the Paris Exposition was awarded the highest gold medal and an additional prize of 14,000 francs. John Brown & Co., of Sheffield, have taken a license to operate under these patents from the English company controlling the patents for that country. The Michigan Steel Works, at Detroit, are now in operation under this process.

THE Standard Steel Casting Company, Thurlow, Pa., is the only company which so far has put in a bid for furnishing to the Government 100 7-in. and 100 11-in. steel shells. Their bid is: Seven-in. shells, $66.85 each; 11-in. shells, $135 each. No award has been made.

THE Reliance Steel Casting Company is the name of a new company recently organized at Pittsburgh to engage in the manufacture of steel castings. It is at present erecting a building 50 × 135 ft. in that city. Charles Bailey, who was for some years Assistant Superintendent of the Pittsburgh Steel Casting Company, is chairman of the new company.

THE War Department has awarded the contract for furnishing castings and forgings for a 10-in. rifle to the Standard Steel Casting Company of Thurlow, Pa., at 27 cents per pound. The contract for furnishing the army with forgings for three hoops and parts of breech mechanism for a 10-in. steel wire gun has been awarded to the Bethlehem Iron Company, of South Bethlehem, Pa., at 40 cents per pound for certain of these forgings, and $1 per pound for the breech mechanism forgings.

THE Seattle Iron & Steel Manufacturing Company, of Seattle, Washington Territory, has been organized. The capital stock will be placed at $100,000, and may be increased to $500,000. The works will be built at Salmon Bay, near Seattle, where the company has purchased 20 acres of land adjoining the Seattle, Lake Shore & Eastern Railroad tracks.

Bridges.

WORK is in progress at Messrs. A. & P. Roberts & Co.'s Pencoyd Iron Works on the superstructure of the new bridge which is to cross the Schuylkill River at the Falls of Schuylkill, Philadelphia, to connect the Philadelphia & Reading Railroad Company's main line with the Port Richmond Branch, to accommodate the Baltimore & Ohio through trains to New York. The bridge is to be of iron, resting on stone piers and approaches, and will be a plate-girder bridge.

THE Wrought Iron Bridge Company, of Canton, reports a heavy business. Among its late contracts is the building of the second viaduct for the Denver City Cable Railway Company, at Denver, Col., to be 3,000 ft. long; they now have under way a like viaduct 2,800 ft. long for the same company; four new steel bridges and the repair of the fifth one in Wood County, W. Va., destroyed by the recent floods.

THE Smith Bridge Company, Toledo, O., has been awarded the contract for building the bridge over the Tennessee at Chattanooga, Tenn. Neely, Smith & Co., of Chattanooga, were awarded the contract for the substructures. The contract for the superstructure was let at $122,361, and for the substructure at $96,198. The bridge will be 2,370 ft. long, and will be 100 ft. above low-water mark, obviating the necessity for a draw.

THE Allentown Rolling Mill Company is building a bridge over Jordan Creek, in Allentown, Pa. It is a plate-girder span, 93½ ft. long.

OBITUARY.

ISAAC PRATT CHAMBERS, who died in Saratoga, N. Y., August 16, aged 53 years, was born in Malden, Mass., and entered the office of the Hudson River Railroad Company as a boy of 19 about 34 years ago. In 1864 he was placed in charge of the New York offices; in 1872 he was appointed Auditor of the New York Central & Hudson River Company, and in 1883 General Auditor and Controller. For some years also he acted as Secretary to the President. Mr. Chambers was one of the best railroad accountants in the country, and was considered a high authority on all questions of railroad business and traffic.

WILLIAM THAW, who died in Paris, August 17, aged 71 years, was born in Pittsburgh. He began business in his father's bank in 1834, and eleven years later formed a partnership with Thomas S. Clarke, as Clarke & Thaw, transporters and owners of steam and canal-boats. This was continued until the Pennsylvania Railroad was built. Subsequently he became connected with that road and held various official positions. For a number of years past he had been Vice-President of the Pennsylvania Company. Mr. Thaw leaves a very large fortune; he was the largest individual stockholder in the Pennsylvania Railroad Company.

PROFESSOR ELIAS LOOMIS, who died in New Haven, Conn., August 14, aged 78 years, was born in Willington, Conn., and graduated from Yale College in 1830. Three years later he became a tutor in the college. During this period, conjointly with Professor Alexander C. Twining of West Point, he began the first observations in this country to determine the altitude of shooting stars. His first distinct mark in the field of science was made in 1835, while still a tutor at Yale, when, computing the elements of its orbit from his own observations, he discovered Halley's comet on its return to perihelion. A year later he studied at Paris under Arago, Biot, Pouillet, and others. Until 1844 he was Professor of Mathematics and Natural Philosophy in the Ohio Western Reserve College. From that date until 1860 he occupied the chair of Natural Philosophy in the University of the City of New York, which gave him his degree of LL.D. in 1854. In 1873 he was made a member of the National Academy of Sciences. His name was also a distinguished one on the rolls of the different scientific societies of America and Europe.

Professor Loomis is widely known by his series of text-books, embracing the whole scope of mathematical subjects. These became class books in high schools and colleges all over the land. He was also the author of popular treatises on natural philosophy, astronomy, and meteorology. Many of his treatises took the form of contributions to the different scientific publications in this country and in Europe. Not the least work performed by the famous mathematician was his comparison from 1846 to 1849 by telegraph of different longitudes, and also his successful observations determining the velocity of electric fluid on telegraph wires.

PERSONALS.

WILLIAM M. GRAFTON has been appointed Signal Engineer of the Pennsylvania lines west of Pittsburgh, with office at Pittsburgh. This is a new office.

LIEUTENANT J. G. CALIFF, U.S.A., has been relieved from duty as Professor at the State University of Iowa, and ordered to join his regiment, the Third Artillery.

ALEXANDER C. CHENOWETH has been appointed Assistant Engineer in the Public Works Department of New York City, in place of SAMUEL L. COOPER, resigned.

CHARLES S. WRIGHT, Chief Engineer of the New Orleans, Fort Jackson & Grand Isle Railroad, has been made Superintendent, in addition to his present duties.

J. A. FULTON has resigned as Bridge Engineer of the Toledo, St. Louis & Kansas City Railroad, and accepted a similar position on the Lake Shore & Michigan Southern.

FRANCIS F. R. BROWN has resigned the position of Mechanical Superintendent of the Canadian Pacific to become Superintendent of the Dominion Bridge Company, Montreal.

W. H. PRATT, C.E., recently resigned his position with the Edge Moor Bridge Works to become Superintendent of the Mount Vernon Bridge Company's works at Mount Vernon, O.

E. W. GRIEVES is now Master Car-Builder of all the lines of the Baltimore & Ohio Railroad Company. Heretofore he has had charge of the Car Department of the lines east of the Ohio River.

ENSIGN GEORGE W. STREET; ENSIGN JOHN G. TAWRESEY and ASSISTANT ENGINEER LLOYD BANKSON have resigned their respective positions, and have been appointed Assistant Naval Constructors, dating from July 1.

EDWARD F. HOBART, of Las Vegas, N. M., who has been appointed Surveyor-General of New Mexico, is a civil engineer by profession and assisted in the construction of some of the early Western roads, including the old Racine & Mississippi Railroad, now a part of the Chicago, Milwaukee & St. Paul system.

CAPTAIN EDMUND L. ZALINSKI, Fifth Artillery, now abroad, has been detached for a period of four months to obtain military information, under such instructions of the Secretary of War as may be communicated to him. He will return to the United States and rejoin his proper station upon the completion of these duties.

IT is stated that JOHN KIRBY, General Master Car-Builder of the Lake Shore & Michigan Southern, has resigned, and that he will be succeeded by JOHN PATTERSON, late Master Mechanic of the Cincinnati, Indianapolis, St. Louis & Chicago. Mr. Kirby resigns, we understand, with the purpose of retiring from railroad work.

CAPTAIN ERNEST H. RUFFNER has been appointed Major in the Engineer Corps; FIRST LIEUTENANT THEODORE A. BINGHAM to be Captain; SECOND LIEUTENANT MASON M. PATRICK to be First Lieutenant, and CADET E. E. WINSLOW to be Second Lieutenant. These promotions have been made in consequence of the retirement of Colonel John G. Parke.

LIEUTENANT R. P. RODGERS, U.S.N., will shortly be relieved from duty as Chief Intelligence Officer of the Navy Department, and ordered on sea service. He has had charge of the Bureau of Naval Intelligence for four years past, and it is largely due to his thorough and intelligent supervision that the work of the bureau has been systematized, and its publications made to command general attention.

PROCEEDINGS OF SOCIETIES.

American Society of Civil Engineers.—The following circular has been issued by the Secretary:

"I am directed to issue for the information of all concerned the following documents, viz.:

"1. Report of the Special Committee on Uniform Standard Time, presented at the last Annual Meeting of the Society.

"2. List of railway presidents, managers, superintendents, engineers and others, who have at different times given expression in favor of the 24-hour notation.

"The Committee requests me to add:

"The report explains the progress made up to the present time in the movement for the adoption of the 24-hour notation. It is felt that the information is of sufficient importance to be made generally known, especially to railway men throughout the country.

"The question may not appear of pressing importance to any single individual, but, taking into consideration the countless millions of people in all future time to be benefited by the successful adoption of the new notation of the hours of the day, attention to the report is respectfully invited.

"In promoting the movement for reforming our system of reckoning time, in order to secure uniformity, simplicity, and accuracy, the American Society of Civil Engineers requests the sympathetic co-operation and assistance of all who are favorably disposed. Every man has it in his power to influence the movement; even a simple expression of opinion in its favor will do so. All, therefore, who may be so inclined, are invited to fill up the accompanying form and transmit it to the Committee, care of the Secretary."

(The report of the Committee, referred to above, was published in the JOURNAL for May last, page 225.)

Engineers' Club of Cincinnati.—At the 13th regular meeting of the Club there were 31 members present, also two visitors. Two applications for membership were received.

The paper for the evening was by Mr. Ward Baldwin, under the title of "The Method of Calculating Bridge Strains for a Concentrated Rolling Load," in which he presented a review of a method of using a graphical diagram for ascertaining the strains induced in simple girders and trusses by the now almost universally specified rolling-load for railroad bridges, by which method a considerabe saving is made in the calculations required and the work much simplified.

The Club adjourned to meet again in September.

Western Society of Engineers.—At the regular meeting, held July 10, the following persons were elected to membership: Andrew Onderdonk, Max J. L. Towler, H. Russell Smith, H. A. Stoltenberg and A. Bertolet.

Messrs. L. E. Cooley and E. C. Carter were appointed as a committee to prepare a memorial of Mr. Robert G. Turknett, a deceased member.

An interesting letter from Mr. Walter Katte, Chief Engineer of the New York Central, detailing his first connection with the Society, which dates from before the Chicago fire, was read.

After an informal talk on the matter of questions for discussion, the Chairman gave notice that at the next meeting, to be held September 4, the following questions would be before the meeting:

1. As a means of rapid transit, for the older portion of Chicago, would not underground electrical railroads be profitable?
2. Systems of municipal engineering in very large cities.

A paper descriptive of compound lumber will also be read at that time, by G. A. M. Liljencrantz.

Denver Society of Civil Engineers.—At the regular meeting August 13, James Philips Maxwell and John Wellington Nesmith were chosen members. A communication from a committee of the American Society of Civil Engineers asking for the appointment of a committee to confer on the question of affiliation between the Societies was received; Professor P. H. Van Diest, H. T. Aulls, and Robert S. Rochlaub were appointed such a committee.

Messrs. J. R. Maxwell, J. S. Green, Walter H. Graves, R. D. Hobart, and J. C. Ulrich were appointed a committee to act in collecting statistics and presenting facts to the United States Senate Committee on Irrigation on its visit to Denver.

Professor P. H. Van Diest read a paper on Mining in the Island of Sumatra. The mines were opened by the Dutch 250 years ago, but have not been worked for 100 years past, although rich returns were formerly made. Recently a company has been organized to reopen them. The paper was accompanied by maps and diagrams.

Interstate Commerce Commission.—The following circular was issued by the Commission, addressed to all organizations of railroad employés, under date of August 1:

"A knowledge of the facts regarding the relations which exist between the railway corporations and their employés is always of public importance, and may be particularly useful to the Commission in some cases in order to enable it to perform its duties in such manner as best to subserve the interests involved. Believing, therefore, that you will willingly co-operate in obtaining the facts, you are respectfully requested to transmit to this office a reply to the following questions:

"1. Is there an insurance fund, guarantee fund, or any other fund from which the members of your order may receive payment in case of sickness, or accidental injury, or from which their families may draw in case of death? If such fund exists please state when it was established, and whether by the railroad corporation or the employés; how it is accumulated; how maintained, and give any other facts that may be important to a full understanding of its history and workings. If no such fund exists, please state if its establishment was ever attempted; if so, to what extent, if at all, the attempt succeeded, and why it failed.

"2. Does your order insist upon any rules of apprenticeship, and if so, what are they? If a fireman or brakeman can only become engineer or conductor after a term of service, please state what that term is.

"3. In the case of engineers and conductors, are their grades of service recognized either by the order to which the employés belong or by the employing company? If so, what are those grades; and what are the conditions for passing from one to the other? In the case of men engaged in shop work, are promotions made from the ranks of the employés, or are men brought from the outside to fill the positions of foremen and the like? If no recognized custom exists, please state whether it has been the subject of discussion hitherto, and what have been the impediments, if any, to its establishment. Copies of papers or documents bearing upon these questions and calculated to elucidate the subjects will be thankfully received."

AT the same time the Commission issued also the following circular, addressed to general managers of railroads:

"All facts regarding the relations existing between railway corporations and their employés are always of public interest, and may be of importance in determining questions upon which the interest of the employers as well as of the employed may depend.

"The Commission therefore address to you the following inquiries, believing that you will appreciate the purpose of the call, and that you will cheerfully render any assistance that may be within your power to facilitate the gathering of the information which they are designed to elicit:

"1. Is an insurance fund or guarantee fund of any sort provided for the employés of your company on which they have a right to draw in case of sickness or accident, or from which payment may be made to their families in case of death? If such fund exists please state in what manner it was accumulated; how it is maintained; under whose direction it is administered; under what conditions money may be drawn from it, and any other facts respecting it which you may think it important to state. If there are any contracts or other writings or printed documents which will give definite information, and which are in your possession, the Commission would be pleased to receive copies thereof. Please also state the length of time the fund has been established; the reasons which have led to its establishment, and the feeling in respect to it on the part of the employés. If no fund of the sort named exists, please state if any attempt has ever been made to establish one, to what extent, if at all, the attempt succeeded, and why it failed.

"2. Has the company eating or lodging houses for trainmen when away from home, or does it provide reading-rooms or other places of resort? If so, full particulars will be duly appreciated.

"3. Is any provision made by your company for technical education in your shops whereby it seeks to train men for its service? Is there any recognized system of promotion in the service of the company whereby it may be expected the men will be induced to labor for marked efficiency? Are any special rules in force to insure the competency of locomotive engineers and other trainmen?

"Should your own information on any of these subjects be defective, please give the names and addresses of any persons connected with your company who may be able to supply any deficiencies."

Master Mechanics' Association.—The following circular has been issued by Secretary Angus Sinclair, from his office 140 Nassau Street, New York City:

"Below is a list of the Committees appointed by President Briggs to carry on the work of investigation and other business during the year. The name first mentioned is Chairman of each committee. One Associate Member has been placed upon each committee, and it is expected that these will use their efforts to obtain scientific data and to furnish information that may be obtained outside of railroad sources. The Chairman of the various committees are urged to organize the work to be done by the different members, and begin the investigations assigned to them as early as possible, that valuable reports may be prepared in good season for the next Convention. The work of the Twenty-second Convention was greatly facilitated by most of the reports being delivered early.

"1. Exhaust-pipes, nozzles, and steam passages; best form and size in proportion to cylinders. Committee, C. F. Thomas A. W. Gibbs, Ross Kells and John A. Hill.

"2. Compound locomotives; their efficiency as compared with simple engines. Committee, J. Davis Barnett, John Player, H. D. Garrett and F. W. Dean.

"3. Testing laboratories, chemical and mechanical. Committee, Philip Wallis, George Gibbs, G. W. West and D. L. Barnes.

"4. Efficiency of the link, as compared with other valve motions. Committee, James M. Boon, David Clark, H. Tandy and John A. Coleman.

"5. Advantages and disadvantages of placing the fire-box above the frames. Committee, Fred B. Griffith, James Macbeth, W. A. Foster and L. F. Lyne.

"6. Relative value of steel and iron axles. Committee, John Mackenzie, J. S. Graham, John S. Cook and Thomas Shaw.

"7. Brick-arches in locomotive fire-boxes. Committee, T. W. Gentry, Allen Cooke, L. C. Noble and W. A. Smith.

"8. The best means, and the economy of preserving locomotive tanks from corrosion. Committee, W. J. Robertson, Albert Griggs, O. Stewart and Jerome Wheelock.

"9. Purification or softening of feed-water. Committee, W. T. Small, Harvey Middleton, A. W. Quackenbush and John W. Hill.

"10. The best form and size of axles for heavy tenders. Committee, W. Swanston, W. Garstang, James Maglenn and L. R. Pomroy.

"11. The present status of the automatic car-coupler question; and whether this Association can indorse the action of the M. C. B. Association in recommending the vertical plane type as a standard, from a mechanical standpoint. Committee, John Hickey, G. W. Rhodes, Sanford Keeler and M. N. Forney.

"Obituary of George C. Watrous. Committee, C. E. Smart, T. J. Hatswell and S. D. Bradley.

"Obituary of S. W. Haines. Committee, L. H. Turner, William Flahaven and E. Richardson."

Master Car & Locomotive Painters' Association.—The Twentieth Annual Convention will be held in Chicago, beginning September 11 next, and continuing probably three days. The Tremont House will be the headquarters of the Association. A special invitation is extended to car and locomotive painters to join in the Convention, and to become members of the Association. Among the subjects upon which reports are to be made by committees are: Painting the Heated Parts of Locomotives; Inside Finish for Passenger Cars; Filling for Driving-Wheels and Other Rough Castings; the Use of Rubbing Varnish on Cars; Paint and Varnish for Locomotives; Decoration of Locomotives; Formula for Painting the Outside of Passenger Cars.

A number of questions will be submitted for general discussion, including the Treatment of Hard and Soft Woods; Color for Locomotives; Removing Old Paint; Prevention of Rust, and other similar queries.

Master Car-Builders' Association.—Secretary John W. Cloud has issued from his office in Buffalo a circular calling on members to vote on the questions referred to letter-ballot at the Saratoga Convention.

The questions thus submitted to vote are: Journal Box Lid; Wheels, Specifications, and Guarantee; Axle for Cars of 60,000-lbs. Capacity; Brake-gear for Air-brake Cars and Brake-shoe for Iron Beam; Buffers and Carrier-irons for the M. C. B. Type of Coupler, and Length of Draw-bar.

NOTES AND NEWS.

New Ship-Building.—The *Nautical Magazine* has prepared elaborate tables from the reports made to *Lloyd's Register*, showing the number of vessels built last year. There were launched in 1888, 765 vessels, having a total tonnage of 926,523 tons, being an increase of about 16 per cent. over the previous year. Of these vessels 548, with a total tonnage of 788,655, were steamers. England led here, having built 422 steamers with 699,613 tons. Germany was second with 33 ships, and a total of 33,834 tons, and the United States third, with 28 steamers of 15,496 tons. Of new sailing vessels, there were 217 built, having a total tonnage of 137,868. Here, again, England led with 62 ships of 77,380 tons, while the United States came second, with 45 vessels with 22,702 tons. It may be noted that while the average tonnage of the steamers built last year showed an increase of 8¼ per cent. over the previous year, the average tonnage of the sailing vessels was nearly the same.

As to material, of the total number of vessels built last year, 451 were of steel, 106 of iron, 203 of wood, and 5 composite. The wooden vessels were chiefly sailing vessels, only 48 of the steamers being of that material, while 408 were of steel and 88 of iron. The chief builders of wooden sailing vessels were the United States, Canada, and Norway, while Great Britain, Germany, and France were the three leading builders of steel and iron ships, Great Britain standing very far in advance of the others.

The most notable feature is the great increase in the number of steel ships, from which it would appear that steel is very rapidly taking the place of iron as a ship-building material.

It seems apparent that there is a renewed activity in ship-building, and that the depression in that industry which has existed for several years is passing away. Whether this is to be followed by another period of low freights and depression remains to be seen.

The Hydraulic Railroad.—This is a novelty attracting much attention at Paris just now. It is the development of an old project of Girard, the well-known French hydraulic engineer. The trains are without locomotives and the carriages without wheels, being supported on broad rails raised some distance above the ground by metal blocks. Before the train is set in motion water under pressure is forced through valves in these bearing blocks, so that the latter are lifted off the rails and are carried on a thin film of water. The same agency is employed to propel the trains, a pipe, conveying water under pressure, being laid in the center of the track; from this pipe at short intervals rise stand-pipes with peculiar shaped nozzles controlled by a tap. Beneath each carriage is a long frame in which are a number of pallets, the surface of which can be acted on by the jet escaping from the nozzles. The action is extremely simple; the train being water-borne, and, therefore, having its friction reduced to a very great extent, is set in motion, and as soon as it passes the first stand-pipe opens the valve controlling the nozzle, when a stream of water under pressure is forced against the pallets under the carriages, accelerating the speed of the latter. As soon as each carriage passes, the valve controlling the nozzle is shut, and remains closed until the succeeding carriage opens it. The plans of M. Girard have been worked out in their present form by M. Barré, who claims many advantages for the system. The length of line laid down on the Esplanade des Invalides is about 200 yards, and the speeds attained are very considerable. The system possesses many points of great interest.—*Engineering.*

Measuring High Temperatures.—The last report of the Secretary of the Observatory of Yale University to the Managers contains the following:

"Although every certificate issued from this Observatory, for other than clinical thermometers, contains a statement of the only conditions under which the correction therein given can be truthfully applied, we are continually called upon to explain, especially in the case of high temperature thermometers, that when only the bulb is immersed in a liquid of high temperature the indicated temperature is too low by an amount depending upon the number of degrees of the mercury in the cooler stem and the difference between the temperatures of the bulb and stem. We have been called upon to show frequently that this error, which is independent of any correction due to the thermometer, may be as much as 8° or 9° in the case of high temperature oils, as their temperatures are generally measured. A simple remedy for this indefiniteness of measurement would seem to be a special form of thermometer in which nearly all the mercury should be immersed. As a result of considerable correspondence with parties interested in the accuracy of measurements of this sort, it was suggested that this Observatory should be represented at a convention held last January, but as it did not appear that the expense to the Observatory would be covered by the compensation likely to be received from this class of work, and the funds were wanting to enable us otherwise to render this public service, no encouragement was given to tender the proposed official invitation."

The Russian Navy.—At the present day the Russian Navy possesses several modern-typed war ships, which for thoroughness of construction and display of inventive genius certainly do great credit to that nation. Like the majority of other nations, the innovations which have made their appearance in the Russian Navy have been of comparatively recent date.

In 1864 the armor-clad ship *Petropaulovsk* was launched and in 1865 the *Netron-Menia*, another iron-clad vessel, was finished. These vessels are now classed in an obsolete type, being stricken off the list of efficient sea-going fighting craft. At the present time the old *Petropaulovsk* is serving out the remainder of her days as a receiving and training ship, being cut down to a harbor hulk. Just what has become of the *Netron-Menia* available history does not tell, but it is probable that she has been condemned long ago. In the early part of the decade commencing with 1870 the appearance of a class of vessels known as *Popoffkas*, or circular monitors, marked another offshoot in the Russian naval designs. These *Popoffkas* were designed especially for harbor protection.

It was not until the beginning of this decade that the really effective vessels of the Russian Navy began to make their appearance. The laying down of the keels of such vessels as the *Vladimir, Monomoski, and Dimitri Donskoi*, saw the work of construction commenced on a class of vessels of most formidable types. From this time on, the additions to the Russian Navy have been in cruisers and battle ships fully compatible with the times, and in most respects war vessels carrying armaments of a most formidable nature.

The Russian Navy is divided into two great divisions, known respectively as the "Baltic fleet" and the "Black Sea fleet." Each of these fleets is again divided into squadrons, of which there are three in the Baltic and two in or near the Black Sea. These two divisions constitute the naval defence at home in time of peace. In addition to the Baltic and Black Sea fleets are the various squadrons which are at all times on foreign stations. In the event of war they would be recalled to Russian waters, and either made a part of the naval defence or broken up.

The Baltic fleet comprises the greater number of armor-clad vessels, though several of the armored war ships in the Black Sea division are far the superiors of the great mass of vessels composing the divisions of the Baltic. There are no less than 31 complete armor-clad ships in the Baltic fleet, including 13 low freeboard or coast-defence ships, one unarmored frigate, five steam corvettes, and 11 first-class torpedo boats. Besides the foregoing there are four unarmored cruisers, one torpedo cruiser, three seagoing steamers, 15 gunboats, and 50 various craft, which include transports, training ships, and receiving vessels.

The Black Sea fleet includes the *Catherine II.*, the *Tchesma*, and the *Sinope*. In addition there are two *Popoffkas*, one cruiser, six gunboats, 10 armed steamers, one torpedo cruiser, 11 torpedo boats, and some 15 other craft of various types.

The most powerful vessels of the Russian Navy are the *Catherine II., Tchesma, and Sinope*. They were launched in 1886—the first two on the Black Sea. They are sister ships. Their dimensions are as follows: Length between perpendiculars, 320 ft.; greatest beam 69 ft.; mean draft, 26 ft. Prior to the advent of these three ships the most powerful vessel of Russia was the *Peter the Great*. This latter vessel was built at St. Petersburg and was the pride of all the Russias. She was built somewhat after the design of the British iron-clad *Dreadnaught*, though of larger dimensions. Her present engines are of English make, the original type, which was put in her at St. Petersburg, proving unsatisfactory. The four 12-in. guns of the *Peter the Great* are carried in two turrets.

Next in point of strength come the sister ships *Nicholas I.* and *Alexander II.* These vessels are 326 ft. long and have each a beam of 67 ft. The protecting armor belt of the *Nicholas I.* is 8 ft. wide, and varies from 14 to 4 in. in thickness, backed up throughout by 12 in. of solid oak. The speed of these vessels is about 17 knots per hour.

Next in order come the five belted cruisers mentioned on the list. The *Duke of Edinburgh* and the *General-Admiral* have each a length of 270 ft. between perpendiculars and a beam of 48 ft. They are built of iron and have an armor of 6-in. plates backed with a wood sheathing, which is between the armor and hull. The 6-in. armor, however, is placed only over the vital parts. The battery decks of these latter vessels are unprotected. There is a practically all-around fire to each of the guns.

The *Vladimir, Monomoski, and Dimitri-Donskoï* are the last additions to the Russian Navy of the armor-belted frigate type. They, too, are sister ships, being 295 ft. in length on the water line, with a beam at extreme parts of 52 ft. Their water draft aft is 25 ft., and their best recorded mean speed 15 knots per hour.

The Russians place considerable dependence in the four iron-clad turret ships named after admirals. They are sea-going cruisers, and resemble the *Prince Albert* type of vessels in the British Navy. Their turrets are of 4 6-in. armor plates.

Irrigation in India.—The report of the irrigation branch of the Indian Public Works Department on the irrigation system of the Punjab shows that excellent progress was made during the past year, and that good results were obtained.

This important system has now a total mileage of 3,730 miles of canal and 4,961 miles of distributaries, and during the year under review irrigated an area of 2,250,081 square acres. The system comprises the Swat River Canal, 22 miles; the Western Jumna Canal, 366 miles; the Bari-Doab Canal, 354 miles; the Sirhind Canal, 542 miles, of which 319 run through British territory and 223 miles through Native States; the Lower Sohag & Para Canal, 94 miles; the Sidhnai Canal, 37 miles; the Chenab Canal, of which only 62 miles out of the total length of 115 miles have been completed; the Upper Sutlej Canal, 220 miles; the Lower Sutlej & Chenab Canal, 92 miles; and the Muzuffargarh Canal, 723 miles.

The total area irrigated is now more than one-third larger than it was five years ago. The principal crops grown on the irrigated lands are wheat, cotton, rice, sugar-cane and corn, and have increased very largely during the past year. The

total expenditure of the system for the year was about $735,000, and the returns to the Government amounted to about 4 per cent. on capital expenditure, after deducting all the cost of maintenance.

Helicoidal-wire System.—An interesting application of the method known as the Helicoidal-wire system has recently been made by a Belgian company, at the old Roman marble quarries in Tunis.

The installation of the Société Anonyme Internationale du Fil-Helicoidal in the grounds of the Brussels Exhibition of 1888 exemplified the principal applications of this new method of working quarries. The endless wire cord is sent by the driving-pulley to a tension truck at the end of the yard, and, guided by pulleys with universal joints, is diverted at given points for sawing a mass of concrete and a block of marble, while there are also the following applications: A frame, in which the usual blades are replaced by cords for sawing slabs; a finishing apparatus; and a drill, driven by teledynamic rope, for sinking the shafts by which the cord-carriers are introduced, the whole being driven by a 14 H.-P. engine.

In most quarries, especially those of marble, it is less important to extract the greatest quantity of stone, than to obtain blocks of the form and size desired with as little waste as possible; and this is accomplished in a high degree by the helicoidal cord; while, manual labor being superseded by a regular mechanical operation, there is no need for skilled workmen, but only a few boys to tend the apparatus. A still further saving of labor is effected by the mass being subdivided into blocks of the desired size on the spot where it is quarried.

The rapidity of the operation naturally depends on the hardness of the stone; but it may be put roughly at 10 times as great as that by old methods, while concrete, and such rocks as cannot otherwise be worked, yield to the helicoidal cords. At the Exhibition, the same cord which sawed a block of marble also cut simultaneously a mass of concrete composed of quartz and flint pebbles.

Quarries in France, Algeria, Tunis, Italy, Spain, Germany, Russia, and Finland have been provided with the new apparatus, while it is exclusively used in the marble quarry of Traigneaux, near Philippeville, Belgium. Here the trench 60 centimeters, or nearly 2 ft. wide, which was formerly, as it is still generally in other quarries, made by hand, is superseded by vertical cuts with the helicoidal cord on all faces not detached, and a horizontal cut underneath the mass to be extracted. If the mass be not detached on any side it is necessary to run two cuts 2 ft. apart along one of the faces.

In order to permit the cord to descend, it is also necessary to sink shafts at all the angles of the mass where not detached, in order to receive the pulley-carriers; and this work is now performed mechanically by the drill invented by Mr. Thonar, at the same time preserving the cores for use as columns. It is usual to make three contiguous shafts, and break down the intervening angles; but the number and size of the shafts may be made subservient to the diameter of columns most in demand. The drill, driven by teledynamic cable, requires from 3 to 3½ H.-P., and descends at the rate of about 10 centimeters (4 in.) per hour in Belgian marble.

The endless helicoidal cord, composed of three steel wires varies from 100 to 300 meters in length, receives its longitudinal motion from a fixed engine, the requisite tension being preserved by a weighted truck on an incline. The downward feed is given by screws in the pulley carriers, turned either automatically or by hand; and the helical twist of the cord causes the rotary motion, which is demonstrated by the even wear of the wires. The cord serves as a vehicle for conveying the sand and water, the former of which is the real agent in cutting the stone.

The diameter of cord found most suitable for quarrying is 5½ to 6 millimeters, or less than a quarter of an inch, running at a speed of 4 meters a second, while smaller diameters and quicker speeds are adopted for subdividing the masses. A cut of 10 to 12 centimeters, or more than 4 in. per hour, is obtained for lengths of 3 or 4 meters in Belgian marble. In Quenast porphyry, which it had not before been found possible to saw, a cut of 3 or 4 centimeters, or from 1 to 1½ in. per hour, is obtained.

For quarrying, 2 H.-P. is found sufficient. If the cord should break, it is readily spliced; and a cord of average (150 meters) length will produce from 40 to 50 square meters of sawn surface, before wearing out, when it may be used for fencing. The sawn surface, plane if not smooth, is readily finished by the application of an amalgam of emery with lead, tin, and antimony, used in a machine like that for polishing glass.

New Use for Cork.—There is no subject which has received more attention from car-builders than that of buffer-springs for railroad cars. Stiff springs on passenger cars cause unpleasant shocks to travelers, and on freight cars damage to their contents.

M. Germond Delavigne proposes for this purpose the use of cork. He starts with the fact that a block of this substance 15 mm. (0.591 in.) in thickness can be compressed to 3 mm. (0.118 in.), or one-fifth of its original thickness, and that, when the pressure is removed, it regains its original size in a few minutes.

Buffer and traction springs have been made which are composed of 12 rings of cork 175 mm. (6.890 in.) in diameter and 15 mm. (0.591 in.) in thickness; these springs, used on the small cars of the Lens Coal Company, have given very good results. On the Northern Railroad experiments have been made with a series of 12 rings exposed to a pressure of 1,100 kilogs. per square centimeter (376 lbs. per square inch); after being submitted to this pressure they regained their original thickness in 10 minutes only.—*Le Genie Civil.*

Another New Rapid Transit Project.—In the April JOURNAL we described to our readers a plan devised by an American inventor for making them independent of railroads and other transportation companies, and furnishing them with an apparatus by which they could become their own rapid transit lines, and take the shortest cut through the air in any direction which they pleased. Not every one, however, may be willing to trust him or herself to the tender mercies of winds and cyclones, and it is, perhaps, to meet their objections that another inventor comes, who seeks to provide us with independent rapid transit upon the surface of the earth. His invention is shown in the accompanying illustrations, and while we have not space to enter into all of the somewhat complicated details, the picture will enable our readers to grasp readily the main idea, which is that of storing up, by a system of powerful springs, the muscular power exerted in bending the leg, and giving it out again when the leg is straightened. The inventor estimates that this spring arrangement will so support the body, help the muscles, and prevent waste of power, that the speed and endurance of a man in walking will be far more than doubled; that unheard-of feats in pedestrianism and in running and jumping may be executed, and that our natural locomotive powers will be so increased that we can afford to snap our fingers at rapid transit monopolies.

Fig. 1.

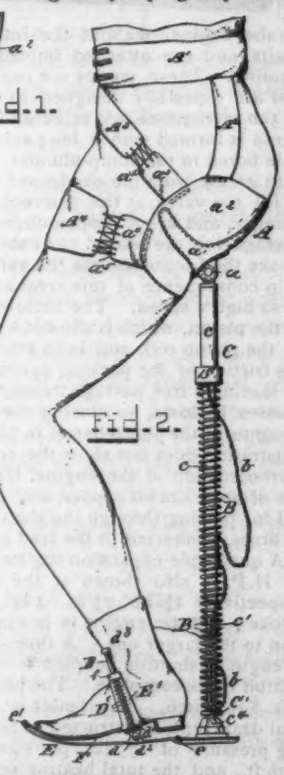


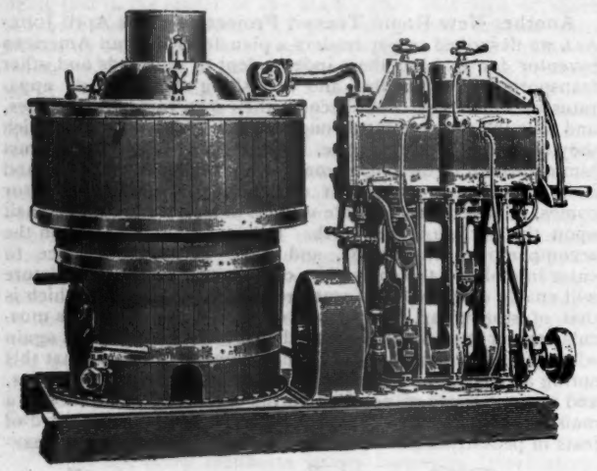
Fig. 2.

The inventor of this system is Nicholas Yagn, of St. Petersburg, Russia, and it is covered by United States Patent No. 406,328, issued under date of July 2 last.

It might possibly be objected to, by fastidious persons, that Mr. Yagn's arrangement would interfere slightly with the style of clothing at present worn by the adult male person; but that is a little detail to which we would soon become accustomed, and which will soon be arranged by general public opinion or consent, as soon as the advantages of his scheme become gen-

erally understood. For ladies, of course, no change of dress will be required.

An English Launch Engine.—The accompanying illustration shows a quadruple-expansion engine intended for a steam launch 50 ft. long and 7-ft. beam, which is exhibited at the Paris Exposition by Simpson, Strickland & Company, of Dartmouth, England. The boiler is intended to carry a working pressure of 175 lbs. The engine, which can exert about 40 H.P., has cylinders 3½ in., 5½ in., 8 in., and 12 in. diameter, with 6½-in. stroke, and is arranged on the tandem type. As will be seen from our illustration, the engine cylinders, which are lagged with teak, are supported on wrought-iron front columns, and a casting at the back on which the guides are formed. The engine is fitted with coupling and link-motion, all working parts being of steel. The feed and air pumps are driven direct from the crosshead



of the engine, without the intervention of levers or weight-shafts, and are attached immediately at the back of the web framing. These pumps are constructed entirely of gun metal, and are especially designed to work at as high a speed as 400 to 500 revolutions per minute. The bottom valve of the feed-pump is formed with a long spindle, made a working fit in a hole bored in the pump-plunger. The spindle, becoming coated with grease from the condensed water, causes sufficient friction to lift the valve at the commencement of the upstroke of the plunger, and keeps it open during the stroke, thus leaving a free passage for the water. At the commencement of the down-stroke the friction causes the valve to close immediately, and it is in consequence of this arrangement that the pump can work at so high a speed. The bottom valve of the air-pump is made in the piston, which is allowed a small amount of vertical motion on the piston rod, and is so arranged that, on the downstroke, the friction of the packing against the bore of the pump raises it, leaving a free passage through the valve, and on the upstroke presses it down, so closing the passage, and compelling the contents of the pump barrel to pass through the top valve. Our illustration does not show the condenser, which is fitted on the starboard side of the engine, but distinct from it. The tubes are of solid drawn copper, and gun metal connections are fitted for passing through the shell of the vessel. The hot-well is of brass, connected to the feed and air pumps by copper pipes.

A quadruple-expansion engine capable of exerting 17 H.P. to 18 H.P. is also shown at the Exhibition. The cylinders are respectively 1¾ in., 2⅝ in., 4 in., and 6 in. diameter by 3½ in. stroke; and the engine is in every respect of similar construction to the larger one. A three-bladed propeller is attached on a length of shafting coupled to the engine shaft, to render the exhibit more complete. The propeller is 1 ft. 8 in. diameter and 4 ft. 8 in. pitch. The boiler is one of Kingdon's vertical natural draft type, constructed of Siemens-Martin steel for a working pressure of 175 lbs. per square inch. The grate surface is 1.76 ft., and the total heating surface, 27 ft.; the tubes, which are of brass, being placed vertically. Owing to the large size of the grate, steam is raised rapidly, and this feature also renders the boiler very efficient when using wood as fuel. The dome and funnel are also of brass, and the greater part of the boiler is lagged with teak. A gun metal hand feed-pump is fitted at the starboard side of the boiler, and a steam blast is also provided for getting up steam quickly. Where weight is limited, and a smaller boiler must be used, a small fan blast is fitted.—*Industries.*

Mississippi Levee Work.—The Mississippi Levee Commissioners give notice that they will receive, at their office in Greenville, Washington County, September 10, bids for the following levee work: Clove Hill, new levee, estimated at 136,000 cu. yds.; Eldorado to Tennessee, 43,000 cu. yds.; Tennessee to Purnell, about one-third new, estimated 67,000 cu. yds. Plans, profiles, and specifications can be seen and other information obtained of William Starling, Chief Engineer of the Commission.

Irrigation in Arizona.—The first attempt at irrigation on a large scale has been begun in Arizona. This Territory has always been regarded popularly as too dry for successful agriculture, but the fact is that the average rainfall in the central part of the Territory is quite as heavy, or even heavier, than in Southern California. The trouble is that the rain nearly all falls in the winter, when it cannot be used for cultivation, and that in the summer there is very little rain, and often none at all. When it does rain the water falls in such quantities that most of it runs off at once and does not benefit the soil. The effort in question has been made by the construction of a large dam at Walnut Grove, 30 miles southeast of Prescott, on the Hassayampa River. At this point there is a wide valley shut in on all sides by high mountains, the only outlet a narrow cañon, through which the water runs. Place a dam across the opening of the cañon where it leaves the valley, and the valley at once becomes a lake-basin. In fact, the geological formation shows that this valley once was an inland lake, the surrounding mountains intact, and the cañon but gradually worn away by the outflowing water. Block up the mouth of the cañon by an artificial dam, and the ancient lake is replaced. This is exactly what has been done in building the storage reservoirs at Walnut Grove.

The dam is of masonry and 110 ft. high, and the water-shed, which serves the river, is about 300 square miles. When the dam was built many, even those who were familiar with the country, doubted whether a sufficient supply could be secured to fill the basin, but in March last the combined effect of a heavy rain-storm and the melting of the snows on the mountains about the head-waters of the river gave a sufficient supply to bring the water up to within 5 ft. of the top of the dam, making a lake three quarters of a mile wide and 1½ miles long, and storing an immense quantity of water, which will be used this summer for irrigating the lands of the valley below.

A Steel Car Truck.—The accompanying engravings show a car truck, the chief feature of which is the cylindrical steel bolster, which is rolled out of a single piece of metal. On this are bolted cast-iron saddles of the form shown, to carry the center-pin, side-bearings, etc., each saddle being provided with

FIG 1.

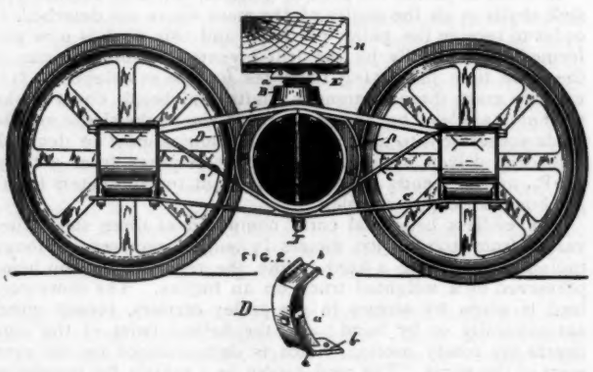
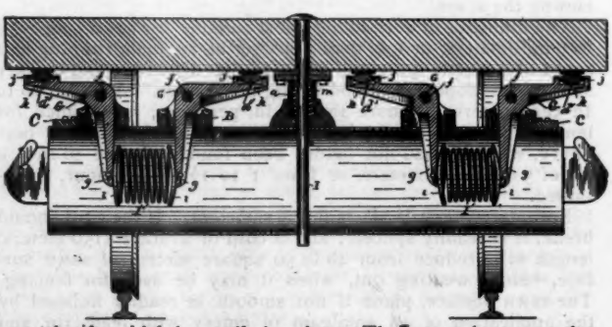


FIG. 2.

FIG. 3.



a socket in which is a coiled spring. The general construction is shown by the engravings, fig. 1 being a side elevation, fig. 2 a view of the brace, and fig. 3 a transverse section.

This truck is the invention of George E. Blaine, of Dayton, O., the patent being No. 404,676, dated June 4, 1889.